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Report On The Determination Of Mass Emissions From Two-Cycle Engine Operated Vehicles

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ABSTRACT:

Two-cycle spark ignited motorcycle engines are evaluated for exhaust emissions from the standpoint of both concentration (percent) and mass (gms/mile) according to current and projected Federal Testing Procedures for light duty vehicles (under 6,000 pound GVW). Seven two-cycle and one four-cycle motorcycle were tested for Carbon Monoxide, Carbon Dioxide, Hydrocarbons, Nitrogen Oxide and Dioxide using Non-Dispersive Infrared, Non-Dispersive Ultra-violet, flame ionization and gas chromatographic analytical techniques. The inconsistencies in the test method as applied to motorcycles are pointed out and suggestions are made for further studies.

CONCLUSION:

The seven two-cycle motorcycles tested per the current Federal test cycle for light duty vehicles under this contract averaged 4429 ppm Hydrocarbon (HC) as Hexane equivalent and 4.34 percent Carbon Monoxide (CO). The corresponding mass figures calculated per those 1970 Federal procedures are 3.59 and 6.81 gms/mile respectively. Calculated per the proposed 1972 procedures (proportional bag sample) the figures are 11.8 and 26.85 grams per mile. A rationale for the discrepancies is suggested, and it is also the author's opinion that of the two test methods employed the precision and accuracy of the 1970 analytical procedures are considerably superior to those of the proposed 1972 method because of long experience with the former and the converse with the latter.

Although one would suspect a priori that the average Carbon number of the exhaust Hydrocarbons from two-cycle engines would be higher than that of four-cycle engines because of the different types of engine lubrication the gas chromatographic data shows a Carbon number well within the expected range for the latter class. This limited data would suggest only a most modest contribution to atmospheric hydrocarbon loading as a lubricating oil contribution.

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Olson Laboratories Incorporated

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INTRODUCTION:

The purpose of this project was to gain a preliminary estimate of both the concentrations and mass emissions from a group of two-cycle motorcycles comprising the most popular makes and displacements. To provide a frame of reference a popular four-cycle engine powered machine was also tested.

Two-cycle engines have been suspect from the standpoint of a high emission potential because of the nature of their combustion process. Appendix C describes two-cycle SI combustion as compared to four-cycle SI engines.

The eight motorcycles tested during this project are described in Table 1. The oldest machine was a 1967 model, the next oldest a 1968, with the balance being 1969's. No formal inspection or tune-up procedures were employed on any of the 'cycles, although they were all road and dynamometer evaluated for proper operation before being tested. All the motorcycles were obtained from either rental agencies or private owners. Within the constraints of sample size it is believed that the 'cycles tested are representative of currently sold and owner operated two-cycle motorcycle engines.

All the machines with the exception of the Yamaha 250 Enduro were tested with Indolene 30 gasoline. Inadvertently the latter 'cycle was tested for both emissions and GC analysis with tank fuel as received. Determination of either the grade or brand of the fuel could not be made on that cycle.

It is of interest to consider the method of lubricating the engines tested in this program. As is generally known the conventional method of lubricating two-cycle engines is simply to add oil to the fuel and intimately mix immediately prior to pouring the fuel into the tank. Alternately one can place the oil in the tank either prior to or subsequent to tank filling with gasoline. The possibilities for gross error in oil to fuel ratios as compared to recommended ratios either way this procedure is carried out are obvious. In the engines that were tested in this program lubrication was supplied from an oil reservoir through a proportioning pump which introduced oil into the engine.

Attached as appendix D is a section from a Yamaha Service Manual which describes in very general terms the operation of their "Autolube" system. Such a system generally adds one quart of oil to every 10 gallons of fuel which represents a 40:1 fuel-oil ratio.

INSTRUMENTATION:

All the 'cycles were tested using the following instrumentation:

1. Beckman Model 315 Low HC analyzer.
2. Beckman Model 315 High HC analyzer.
3. Beckman Model 315 CO analyzer.
4. Beckman Model 315 CO_2 analyzer.
5. Beckman Model 315A NO analyzer.
6. Horiba Model UVA-1 NO_2 analyzer.
7. MSA Flame Ionization analyzer.
8. Clayton Model CT-200 Chassis Dynamometer.
9. Olson Laboratories Variable Volume Constant Mass Sampler

Analyzers numbered 1-5 are all Non-Dispersive Infrared while number 6 is Non-Dispersive Ultra-violet.

TEST PROCEDURES:

All of the motorcycles were tested over the seven-mode HEW cycle. It was recognized that in all probability that the typical motorcycle driving pattern bore little resemblance to the seven-mode cycle, but lacking information on such a driving pattern, the use of the seven-mode cycle would at least allow a comparison of the emissions from the motorcycles to those of motor vehicles now subject to Federal Standards.

The criterion for determining the success of each run was whether or not the acceleration modes could be completed within the times specified by the Federal Register. To accomplish this, the Clayton dynamometer was altered by removing the fixed 2000 pound inertia wheel. As indicated in Table 1, a 500 pound inertia wheel was used for the larger motorcycles to simulate acceleration performance, while inherent system inertia was sufficient for the smaller motorcycles. In all cases the power absorption unit was not used. This practice is commonly adopted in the testing of lightweight, foreign automobiles. Since it has been observed that four-cycle engine exhaust concentration emissions vary little within the broad constraints of horsepower and inertia settings, it is believed that similar results apply to two-cycle vehicles.

The exhaust gas analysis system, as shown schematically in Figure 2, incorporates an Olson Laboratories Variable Volume Constant Mass Sampler. Samples for both the continuous and bag analysis were diluted using the Constant Mass Sampler. This was done to avoid insofar as possible any "wall" effects in the analytical train in view of the expected high Hydrocarbon concentrations. The calibration curve for the Constant Mass Sampler appears in Figure 3 and the method used for calibration of the sampler is described in Appendix E. The desired dilution range was selected as an approximate 10:1 air/exhaust ratio. To achieve this ratio the air delivery was varied in 40 CFM increments until the proper mix was achieved. Figure 4, the calculation sheet for one run on the Yamaha 180, illustrates the dilution ranges encountered. The mass sampler heat exchanger was not cooled, but was actually used as a heat sink to average out the diluted exhaust at temperatures of 46-52° C which further reduces the possibility of condensation of the high molecular weight Hydrocarbons (from the oil) peculiar to this study.

From the diluted exhaust samples continuous analyses were made for

HC, CO, CO_2 and NO over the HEW test cycles. NO_2 and Flame Ionization Hydrocarbons were measured only on the bag samples with the Flame Ionization instrument using a fuel of 60% N_2-40% H_2 with air as the oxidizer. The bag samples were also tested for NDIR HC, CO, NO, and CO_2 concentrations. Samples for the gas chromatographic analysis were drawn from the bag sample into two-liter glass flasks. These samples were packed in dry ice and immediately transported to the subcontractor for analysis. Before introducing the samples to the G.C. the flasks were heated to 70% C by means of a heating mantel.

DISCUSSION OF RESULTS:

The seven-mode cycle "Hot Start" data appears in Table 2. The data was calculated according to the Federal procedures for the 1968 emission standards. The carbon dioxide (CO_2) corrected value also appears in this table. The Hydrocarbon value was added to the total Carbon correction on all modes. The high concentrations of Hydrocarbons encountered significantly affected the correction factors and would have given higher emissions if this factor was only used on the decel modes as prescribed by the Federal Register. In all cases the data shows the engine operating with a rich mixture which is probably characteristic of a two-cycle motorcycle as well as the baseline four-cycle engine. As was mentioned earlier no attempt was made to make adjustments on these motorcycles.

Table 3 is a summary of the diluted bag sample analysis. In comparing the corrected values for Hydrocarbon (HC) and Carbon Monoxide (CO) in Table 3 with those from Table 2, we find an average difference of about 10 per cent. The average Hydrocarbon value obtained for all 8 motorcycles by the 7-mode analysis was 4404 as compared to 3948 for the bag analysis. The respective Carbon Monoxide values were 4.61 and 4.12.

Considering we are comparing a closed verses an open cycle this agreement could be considered quite good. This close agreement however was not shown in the mass emission calculations by the two different methods.

The oxides of nitrogen determined by bag sample analysis were much higher than the seven-mode cycle data. The seven-mode cycle data is the more logical and probably the correct value. The bag samples were probably contaminated from previous tests due to moisture in the system and hang-up. These bags were carefully flushed with clean air between samples but it is obvious from the data that the interference of moisture and NO_2 hang-up was probably contributing greatly to the response.

Mass emissions as determined from these two sets of data appear in Tables 4 & 5. There is a noticeable difference in the mass emissions as determined by these two methods. The oxides of Nitrogen differences are readily explainable by the large concentration differences determined by the two methods. The differences seen between the values for Hydrocarbon and Carbon Monoxide are less easily explained.

The greatest influence on this calculation is the exhaust volume per mile as determined by the two different methods. If one for example takes the V mix calculated in Table 5 for the Yamaha 180 and divides by the correction factor we obtain a corrected exhaust volume per mile of 19.2 which compares to 4.8 as determined by the empirical formulae from the Federal Register (45 CFR § 85.87).

Another difference which affected the results was that the flame ionization data was used to calculate Hydrocarbon emissions in Table 5 (bag samples) and the NDIR multiplied by a factor of 1.8 was used for Table 4. This factor as can be seen by Figure 1 was incorrect as the actual ratio came out 1.33.

Other factors which affected the comparison were the different methods used to determine the correction factors, and inherent errors involved in measurement of temperatures, pressure, and mass flow rates.

Mass emissions calculated by the seven-mode data cannot be expected to agree with the Variable Volume Mass Sampler data. It is obvious from the difference in the calculations and sampling techniques that were used that we really are trying to compare two different things. As to which method is correct, we believe that both methods suffer from inadequacies as these methods were specifically designed for a four-cycle passenger car. This data is presented only as a comparison of emissions based on present sampling procedures.

The large differences between the two methods of calculations shows a need for the development of more appropriate driving cycles and sampling procedures. We can only conclude that the actual emissions found by newer methods will be within the ranges reported.

Table 6 is a summary of the Gas Chromatography data and the complete data by compound appears in Appendix F.

In addition to the actual concentrations of individual compounds the reactivity of each compound has been computed using the G.M. reactivity index[1]. Individual compounds were identified using the data of McEwen[2] and Jackson[3].

The Hydrocarbon names have been abbreviated on the data sheets and the identifications are given in Appendix A. The reactivity of the Hydrocarbons is a measure of its smog forming potential. The higher the reactivity number the faster the Hydrocarbon will react in the smog forming photooxidation reaction.

Appendix B is a typical automobile exhaust calculation of individual Hydrocarbons and reactivity. In comparing this set of data with that determined from the two-cycle emissions we see an order of magnitude difference in both concentration of Hydrocarbons and reactivity. However, the higher emissions from the two-cycle engines should be weighted on a grams per mile basis rather than a per cent or ppm basis as reported. The data does show that the overall reactivity when compared on the basis of Hydrocarbon concentration is nearly equivalent to a typical automobile exhaust. The total Hydrocarbons determined by gas chromatography are very close to the flame ionization data obtained although less in each case. This G.C. data is, however, representative of greater than 90% of the total Hydrocarbons. McEwen[2] reports average Carbon numbers in the range of 3.40 to 5.95. Since the highest average Carbon number reported (5.9) falls within this range and since this particular cycle (Suzuki 250) has oil pumped directly to the main bearings and rod lower end rather than being pre-mixed or injected with the fuel, the contribution of the oil to the Hydrocarbon measured could be considered slight for these two-cycle engines. If the oil were actually contributing to the overall Hydrocarbon measurement we would expect higher average Carbon numbers for the other two cycles.

It should be noted that the Yamaha 250 was not run on the same fuel as the other two motorcycles.

Also, because of the small volume of the tanks and the difficulty of completely draining the tank before filling with the test fuel it would be possible for this residual fuel to affect the overall composition. However, we feel the data as presented is valid for the purpose of obtaining typical emissions of individual Hydrocarbons especially those formed primarily in the engine such as acetylenes and the lower Carbon number paraffins and acetylenes.

CONTRIBUTION TO OVERALL POLLUTION

The U.S. Department of Transportation shows that in 1966 passenger cars traveled a total of 744,844 million miles, motorcycles traveled a total of 6,896 million miles. According to the latest information the two-cycle motorcycles account for 39% of the motorcycle sales.

Using the overall average mass emissions from Table 4 for two-cycle motorcycles and assuming that all passenger cars meet the standards of 2.2 grams per mile of Hydrocarbon and 23 grams per mile of Carbon Monoxide we arrive at the following information:

1. Two-cycle motorcycles emit 0.65 of the passenger car Hydrocarbon emissions and 0.11 of the Carbon Monoxide emissions.
2. This amounts to approximately 11,300 tons per year of Hydrocarbons and 20,100 tons per year of Carbon Monoxide.

Figure 5 is a graph comparing the range of Hydrocarbons experienced on a single device equipped passenger car as compared with the motorcycle emissions on a grams per mile basis as determined from Table 4. The Carbon Monoxide emissions are significantly lower than the passenger car but the Hydrocarbon range is greater by approximately a factor of 3. Therefore, even though the motorcycles at present represent a small percentage of the total overall vehicle emissions as the cycle becomes more popular it could be a significant contributor to air pollution in the near future.

According to the U.S.D.T. study there was an increase in sales of motorcycles of 32.4 percent form 1965 - 1966. More up-to-date information on 'cycle population and other two-cycle engine machines such as boats, lawn-mowers, chain saws and ski-mobiles would most likely show an even more significant contribution to air pollution than we can presently estimate.

SUGGESTIONS FOR FURTHER STUDY

Before a more accurate picture of overall two-cycle emissions can be determined a study of actual population types and numbers should be made of all two-cycle engine machines. Also, a study should be made of driving or operating conditions peculiar to the various types. With this type of information and equipment designed around these operating parameters and using the most advanced types of instrumentation available a study should be made which would give us a more accurate index of the contribution the two-cycle engine is making to air pollution.

REFERENCES:

1. C.S. Tuesday and W.A. Glasson, "Hydrocarbon Reactivity in the Atmospheric Photo-oxidation of Nitric Oxide". Paper presented at ACS Meeting, Atlantic City, September 1965.

2. D.J. McEwen "Automobile Exhaust Hydrocarbon Analysis by Gas Chromatography", Anal. Chem. Vol. 38 (1966) page 1047.

3. M.W. Jackson "Effects of Some Engine Variables and Control Systems on Composition and Reactivity of Exhaust Hydrocarbons". SAE Transaction Vol. 75, 1967, page 114, SAE publication #660404.

Table 1

Vehicle Identification

Manufacturer	Displacement CC	Vehicle Weight Pounds	Model Year	Mileage	Dyno Inertia[3] Pounds
Honda[1]	350	325	1969	New	500
Yamaha	180	300	1968	6282	Rolls only
Yamaha	100	212	1969	736	Rolls only
Yamaha	50	174	1969	1292	Rolls only
Yamaha	80	185	1967	11916	Rolls only
Yamaha	305	384	1969	1249	500
Suzuki	250	325	1969	28	500
Yamaha Endura[2]	250	275	1969	No Odometer	500

1. Four-cycle engine.
2. Used premixed fuel-oil mixture of 40:1
3. Horsepower absorption unit not used.

TABLE 2

SUMMARY OF CONTINUOUS 7-MODE CYCLE NON-DISPERSIVE INFRARED ANALYSIS

Vehicle	HC/NDIR	CO %	NO ppm	CO_2 %
Honda 350 4-cycle				
Run #1	602 ppm	6.43 %		8.18 %
Run #2	558 ppm	6.63 %	292 ppm	8.04 %
Run #3	585 ppm	6.50 %	297 ppm	8.14 %
Average	582 ppm	6.52 %	294 ppm	8.13 %
Yamaha 180 2-cycle				
Run #1	4260 ppm	2.79 %	171 ppm	9.63 %
Run #2	4785 ppm	1.92 %	242 ppm	10.20 %
Run #3	4632 ppm	2.84 %	297 ppm	9.39 %
Average	4560 ppm	2.52 %	237 ppm	9.74 %
Yamaha 100 2-cycle				
Run #1	3585 ppm	4.26 %	208 ppm	8.59 %
Run #2	3963 ppm	3.73 %	185 ppm	8.89 %
Run #3	3600 ppm	4.58 %	84 ppm	8.22 %
Average	3716 ppm	4.19 %	159 ppm	8.57 %
Yamaha 50 2-cycle				
Run #1	3299 ppm	3.68 %	319 ppm	9.34 %
Run #2	4204 ppm	3.14 %	369 ppm	9.22 %
Run #3	3993 ppm	3.64 %	450 ppm	8.98 %
Average	3832 ppm	3.49 %	379 ppm	9.18 %

TABLE 2 Cont'd

SUMMARY OF CONTINUOUS 7-MODE CYCLE NON-DISPERSIVE INFRARED ANALYSIS

Vehicle	HC/NDIR	CO %	NO ppm	CO_2 %
Yamaha 80 2-cycle				
Run #1	2407 ppm	1.65 %	368 ppm	11.90 %
Run #2	2282 ppm	1.76 %	244 ppm	11.86 %
Average	2345 ppm	1.70 %	306 ppm	11.82 %
Yamaha 305 2-cycle				
Run #1	5840 ppm	6.62 %	100 ppm	4.61 %
Run #2	6166 ppm	6.55 %	159 ppm	5.34 %
Run #3	5996 ppm	6.58 %	114 ppm	4.82 %
Run #4	6447 ppm	3.19 %	546 ppm	7.95 %
Average	6112 ppm	5.73 %	230 ppm	5.68 %
Suzuki 250 2-cycle				
Run #1	5155 ppm	6.10 %	130 ppm	6.17 %
Run #2	4248 ppm	5.83 %	158 ppm	6.61 %
Run #3	4483 ppm	6.59 %	126 ppm	5.71 %
Run #4	4628 ppm	7.46 %	434 ppm	4.76 %
Average	4629 ppm	6.50 %	212 ppm	5.81 %
Yamaha 250 2-cycle				
Run #1	5603 ppm	6.54 %	94 ppm	5.10 %
Run #2	5674 ppm	6.22 %	168 ppm	5.37 %
Run #3	6141 ppm	6.19 %	137 ppm	5.10 %
Average	5806 ppm	6.31 %	133 ppm	5.19 %

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Table 3

Summary Of Corrected & Uncorrected Bag Sample Data (NDIR, NDUV & FI)

Vehicle & Test No.	HC/NDIR ppm Hexane	HC/FID ppm Hexane	CO %	NO ppm	NO_2 ppm	NO_x ppm	CO_2 ppm
Honda 350							
Run #1	455	750	2.30				3.10
Run #2	365	750	2.20	125	36	161	2.75
Run #3	375	750	2.05	100	14	114	2.65
Average	398	750	2.18	113	25	138	2.83
Correction Factor: 2.73							
Average Corrected:	1,087	2,048	5.95	308	68	377	7.73
Yamaha 180							
Run #1	490	595	.35	25	74	99	.87
Run #2	490	595	.28	25	109	134	.85
Run #3	490	690	.26	37	138	175	.80
Average	490	627	.30	29	107	136	.84
Correction Factor: 10							
Average Corrected:	4,900	6,265	3.0	290	1,070	1,360	8.40
Yamaha 100							
Run #1	350	525	.40	37	81	118	.62
Run #2	375	550	.41	25	92	117	.62
Run #3	390	550	.46	12	97	109	.62
Average	372	542	.44	25	90	115	.62
Correction Factor: 11.03							
Average Corrected	4,103	5,973	4.85	276	993	1268	6.84

Table 3 - Cont'd

Summary Of Corrected & Uncorrected Bag Sample Data (NDIR, NDUV & FI)

Vehicle & Test No.	HC/NDIR ppm Hexane	HC/FID ppm Hexane	CO %	NO ppm	NO_2 ppm	NO_x ppm	CO_2 ppm
Yamaha 50							
Run #1	220	300	.21	50	90	140	.55
Run #2	275	410	.18	75	102	177	.55
Run #3	240	390	.18	62	76	138	.55
Average	245	367	.19	62	89	152	.55
Correction Factor: 15.31							
Average Corrected	3,751	5,611	2.91	949	1,363	2327	8.42
Yamaha 80							
Run #1	150	250	.07	50	56	106	.67
Run #2	145	250	.08	75	56	131	.62
Average Uncorrected	148	250	.08	63	56	119	.65
Correction Factor: 16.48							
Average Corrected:	2,439	4,120	1.32	1038	923	1961	10.71
Yamaha 305							
Run #1	630	920	.48	25	169	194	.60
Run #2	630	900	.49	37	187	224	.46
Run #3	640	900	.52	50	187	237	.67
Run #4	685	920	.44	12	156	168	.62
Average	646	910	.48	31	175	206	.59
Correction Factor: 9.32							
Average Corrected:	6,021	8,481	4.47	289	1631	1920	5.50

Table 3 - Cont'd

Summary Of Corrected & Uncorrected Bag Sample Data (NDIR, NDUV & FI)

Vehicle & Test No.	HC/NDIR ppm Hexane	HC/FID ppm Hexane	CO %	NO ppm	NO_2 ppm	NO_x ppm	CO_2 ppm
Suzuki 250							
Run #1	1000	1355	.83	37	200	237	.70
Run #2	815	1210	.76	37	66	103	.71
Run #3	860	1210	.80	37	80	117	.65
Run #4	1325	2030	.93	175	95	270	.55
Average	1000	1452	.83	72	110	182	.65
Correction Factor: 6.38							
Average Corrected:	6380	9261	5.30	459	702	1161	4.15
Yamaha 250							
Run #1	790	950	.63	50	102	152	.60
Run #2	845	970	.66	12	124	136	.67
Run #3	780	1020	.59	37	86	123	.60
Average	805	980	.63	33	104	137	.62
Correction Factor: 8.15							
Average Corrected:	6561	7987	5.13	269	848	1117	5.05

TABLE 4

MASS EMISSIONS AS DETERMINED FROM 7-MODE CYCLE DATA [1]

	Inertia [2]	Exhaust Volume Cu.Ft.Per Mile [3]	HC g/mi	CO g/mi	NO_x g/mi
Honda 350	500	6.0	0.62	12.95	0.096
Yamaha 180	450	4.8	3.86	4.0	0.062
Yamaha 100	350	2.5	1.64	3.47	0.022
Yamaha 50	325	1.9	1.28	2.2	0.039
Yamaha 80	335	2.14	.88	1.20	0.036
Yamaha 305	500	6.0	6.48	11.38	.075
Suzuki 250	500	6.0	4.9	12.91	.069
Yamaha 250	500	6.0	6.14	12.53	0.043
Average 2-cycle only			3.59	6.81	0.049

1. Average values from Table 2 used for calculations.
2. Determined either by dynamometer loading or by the vehicle weight plus 150 pounds.
3. Calculated per 45 CFR § 85.87

Mass Emission Equations:

$$\text{HC Mass} = \frac{\text{ppm Hexane}}{10^6} \times 1.8 \times 6 \times \frac{\text{Exhaust Volume}}{\text{Mile}} \times \text{Density HC}$$

$$\text{CO Mass} = \frac{\%\ \text{CO}}{100} \times \frac{\text{Exhaust Volume}}{\text{Mile}} \times \text{Density CO}$$

$$\text{NO Mass} = \frac{\text{ppm NO}}{10^6} \times \frac{\text{Exhaust Volume}}{\text{Mile}} \times \text{Density } NO_2$$

Table 5

Mass Emission As Determined From Variable Dilution Bag Sampler Data [1]

	V_{mix} Cu.Ft./Mile[3]	HC g/m[2]	CO g/m	NO_x g/m
Honda 350	91.8	6.75	66.0	0.69
Yamaha 180	192.0	11.8	19.1	1.42
Yamaha 100	91.0	4.83	13.3	0.57
Yamaha 50	91.5	3.28	5.76	0.76
Yamaha 80	92.3	2.26	2.45	0.60
Yamaha 305	185.0	16.5	29.4	1.76
Yamaha 250	186.0	26.5	51.2	1.84
Yamaha 250	185.0	17.8	38.6	1.39
Average For 2-cycle engines		11.8	26.85	1.19

[1] Average values from Table 3 were used for these calculations.

[2] As determined by Flame Ionization.

[3] V_{mix} = Diluted exhaust volume in cubic feet per mile, corrected to standard conditions.

Mass Emission Equations:

$$\text{HC Mass} = \frac{\text{ppm Propane}}{10^6} \times 3 \times \text{Vmix} \times \text{Density HC}$$

$$\text{CO Mass} = \frac{\%\ \text{CO}}{100} \times \text{Vmix} \times \text{Density CO}$$

$$\text{NO Mass} = \frac{\text{ppm NO}}{10^6} \times \text{Vmix} \times \text{Density } NO_2.$$

Table 6

Summary Of Gas Chromatography Data [1]

	Test #1 Yamaha 250	Test #2 Yamaha 305	Test #3 Suzuki 250
Total Paraffins PPM Carbon	25239.91	21414.2	25698.69
Average Carbon Number	5.01	5.41	5.69
Total Paraffins PPM	5038.97	3958.61	4514.7
Percent Paraffins	56.79	45.83	57.02
Reactivity (G.M.)	6044.73	5053.94	5880.47
Total Olefins PPM Carbon	8397.21	8990.99	4270.41
Average Carbon Number	4.08	4.48	4.74
Total Olefins PPM	2059.82	2007.28	900.23
Percent Olefins	23.21	23.24	11.37
Reactivity (G.M.)	16785.9	18998.6	9247.14
Total Aromatic PPM Carbon	9579.73	18777.27	15922.49
Average Carbon Number	7.77	8.13	7.59
Total Aromatics PPM	1232.29	2309.94	2098.32
Percent Aromatics	13.89	26.74	26.50
Reactivity (G.M.)	3883.32	7540.09	5834.11

Table 6 Continued

Summary Of Gas Chromatography Data [1]

	Test #1 Yamaha 250	Test #2 Yamaha 305	Test #3 Suzuki 250
Total Acetylenes PPM Carbon	1090.34	728.57	811.57
Average Carbon Number	2.01	2.02	2.01
Total Acetylenes PPM	542.18	361.19	404.41
Percent Acetylenes	6.11	4.18	5.11
Reactivity (G.M.)	23.28	24.18	10.72
Grand Totals:			
PPM Carbon	44307.07	49911.03	46702.89
PPM Hexane	7384.523	8318.5	7783.844
PPM Compound	8873.133	8636.875	7917.52
Reactivity (G.M.)	26737.24	31616.88	20972.5
Maga Index	0.625	0.723	0.674
G.M. Index	3.013	3.661	2.649
Average Carbon Number	4.993	5.779	5.899

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[1] All data corrected by the factor $\frac{15}{CO + CO_2 + 6\ HC}$

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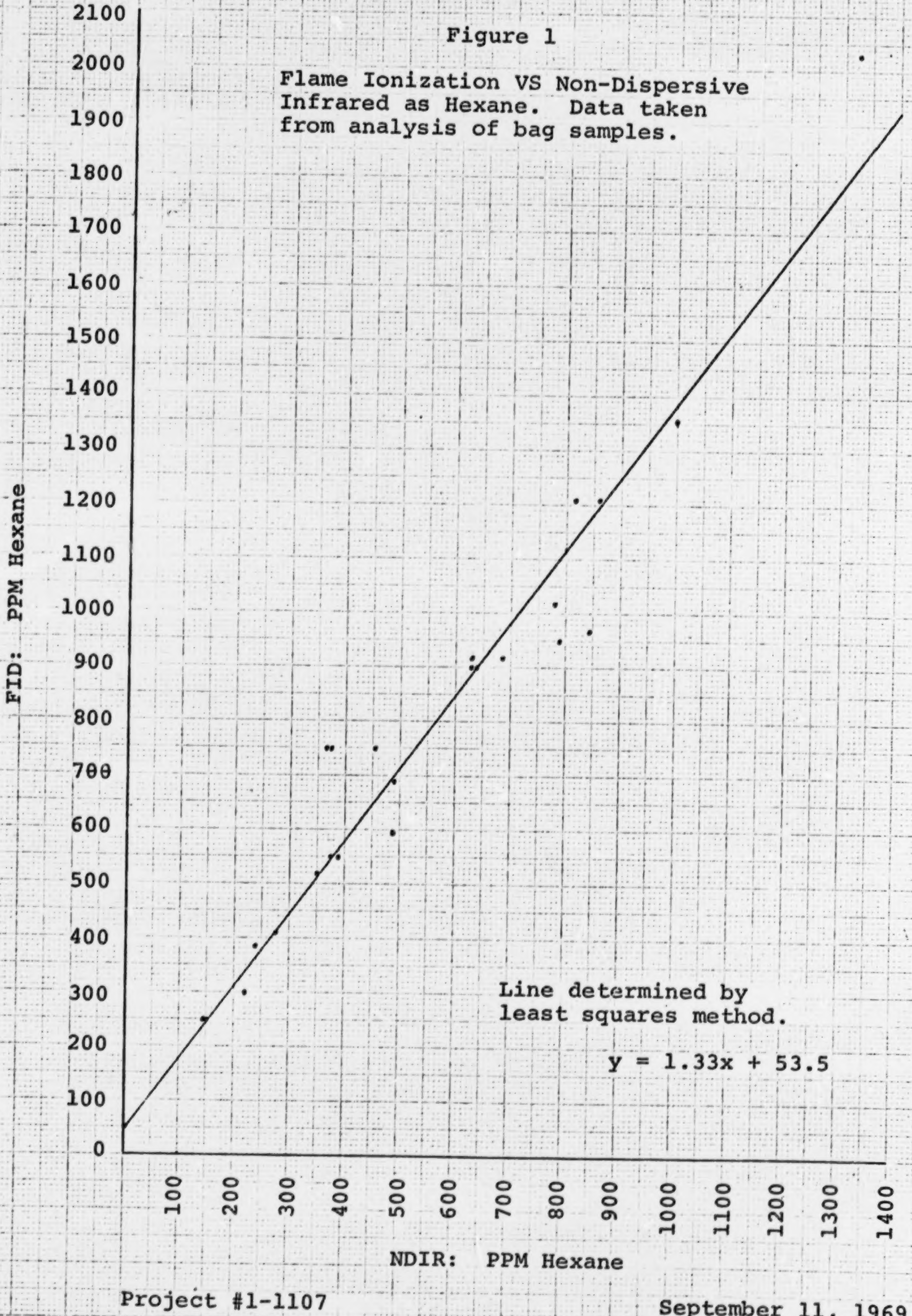


Figure 1

Flame Ionization VS Non-Dispersive Infrared as Hexane. Data taken from analysis of bag samples.

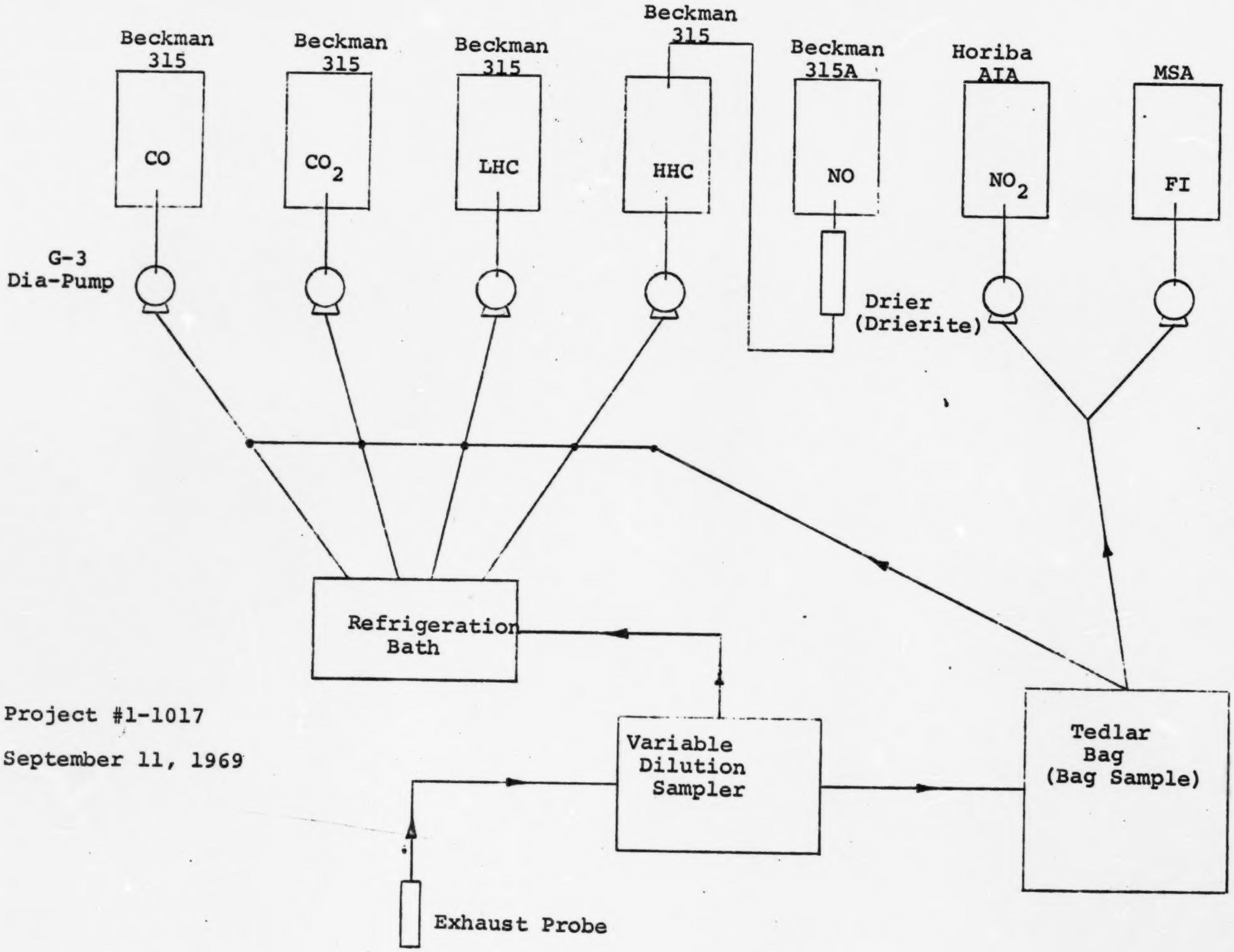
Line determined by least squares method.

$y = 1.33x + 53.5$

Project #1-1107

September 11, 1969

10 Millimeters to the Centimeter


Beckman 315
CO
Beckman 315
CO_2
Beckman 315
LHC
Beckman 315
HHC
Beckman 315A
NO
Horiba AIA
NO_2
MSA
FI
G-3 Dia-Pump
Drier (Drierite)
Refrigeration Bath
Variable Dilution Sampler
Tedlar Bag (Bag Sample)
Exhaust Probe

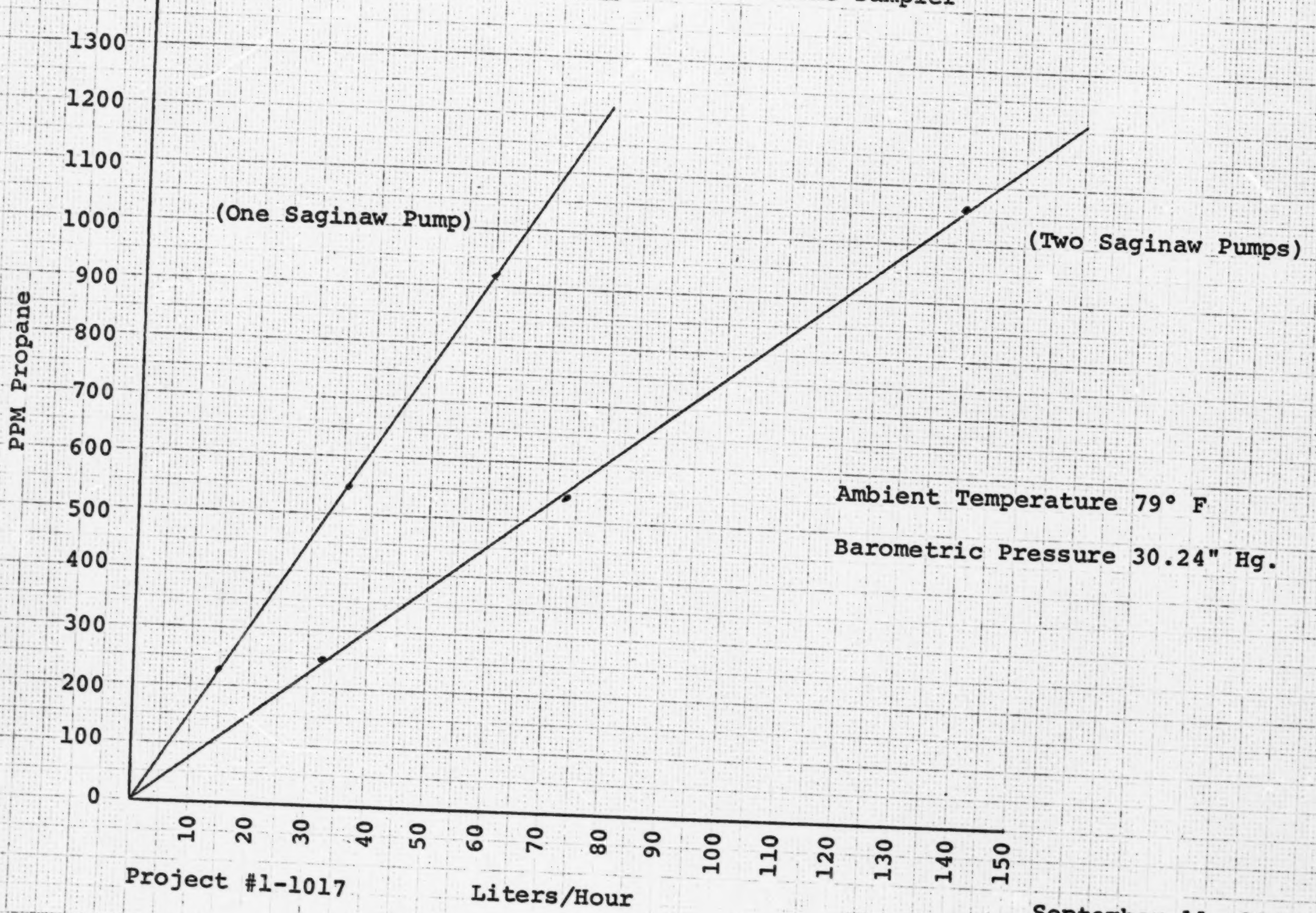
Project #1-1017

September 11, 1969

(Figure 2) Flow Schematic for Exhaust Gas Analysis System

Figure 3

Calibration Curve For OLI Constant Volume Sampler



Ambient Temperature 79° F

Barometric Pressure 30.24" Hg.

Project #1-1017

September 11, 1969

NATIONAL 12-188

10 Millimeters to the Centimeter

Figure 4
EXHAUST CONCENTRATION DATA

Date 7-25-69 Project No. 1-1107 Vehicle Yamaha 180 Run No. 319

Odometer

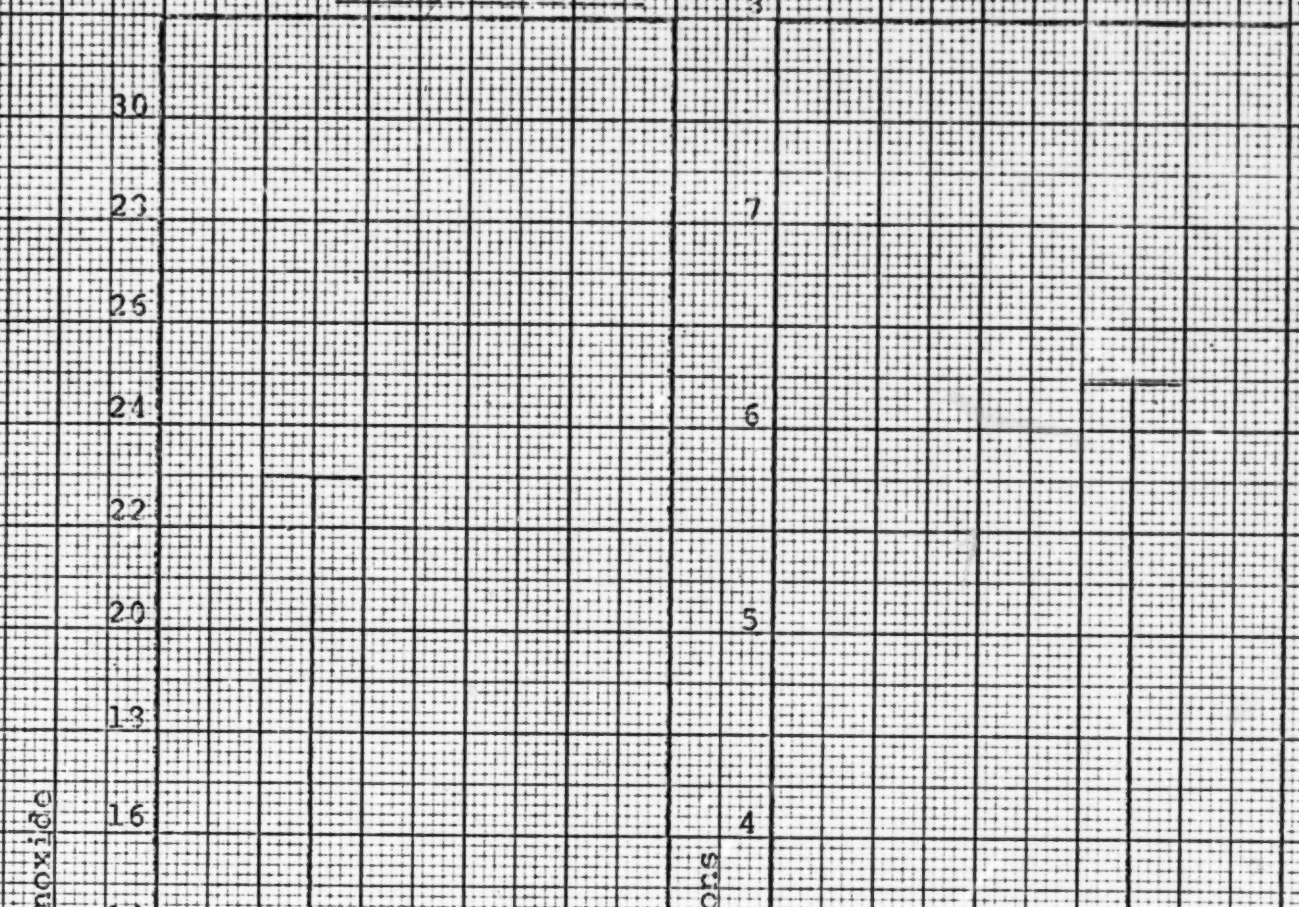
Device

Cycle	MODE	HC		CO		CO2		15 / CO-CO2 Factor	CORRECTED		Weight Factor			TOTAL WEIGHT VALUE
		Meter	ppm	Meter	%	Meter	%		HC ppm	CO %		HC ppm	CO %	
1	Idle		198		.08		.17	40.67	8053	3.25	.042	338	.14	
	0-25		565		.58		1.12	7.36	4156	4.27	.244	1014	1.04	
	30		375		.25		1.35	8.22	3082	2.05	.118	364	.24	ppm HC
	30-15		286		.11		.50	19.19	5488	2.11	.062	340	.13	4315
	15		405		.08		.74	14.11	5714	1.13	.050	286	.06	
	15-30		450		.29		1.25	8.29	3729	2.40	.455	1697	1.09	% CO
	50-20		450		.15		.29	21.13	9508	3.17	.029	276	.09	2.79
2	Idle		187		.07		.17	42.59	7964	2.98	.042	334	.12	
	0-25		385		.26		1.07	9.61	3699	2.50	.244	902	.61	
	30		425		.45		1.37	7.23	3072	3.25	.118	362	.38	ppm HC
	30-15		315		.15		.50	17.88	5632	2.68	.062	349	.17	4204
	15		385		.05		.72	14.98	5767	.75	.050	288	.04	
	15-30		475		.38		1.25	7.81	3709	2.97	.455	1688	1.35	% CO
	50-20		475		.21		.24	20.41	9695	4.29	.029	281	.12	2.79
3	Idle										.042			
	0-25										.244			
	30										.118			ppm HC
	30-15				HC =	4260 PPM					.062			
	15				CO =	2.79%					.050			
	15-30										.455			% CO
	50-20	Bag Sample									.029			
4	Idle										.042			
	0-25		490		.35		.87	9.91	4855	3.47	.244			
	30										.118			ppm HC
	30-15				HC =	4855 PPM					.062			
	15				CO =	3.47%					.050			
	15-30										.455			% CO
	50-20		FID	1190 propane							.029			
6	Idle		30.12" Hg;	Two Pumps;	40°C						.042			
	0-25										.244			
	30										.118			ppm HC
	30-15										.062			
	15										.050			
	15-30										.455			% CO
	50-20										.029			
7	Idle										.042			
	0-25										.244			
	30										.118			ppm HC
	30-15										.062			
	15										.050			
	5-30										.455			% CO
	50-20										.029			

NO ppm ________ 4260 HC ppm 2.79 CO

GRAPH PAPER GRAPHIC CONTROLS CORPORATION Buffalo, New York Printed in U.S.A.

FIGURE 5



Comparison of emissions of 2-cycle motorcycles and device equipped passenger cars.

AS-0813-C 10 X 10 TO THE HALF INCH SQUARE

APPENDIX.

APPENDIX A
HYDROCARBON CODE IDENTIFICATION

PARAFFINS

---	METHANE
---	ETHANE
---	PROPANE
IB	I-BUTANE
NB	N-BUTANE
IP	I-PENTANE
NP	N-PENTANE
22DMB	2,2-DIMETHYLBUTANE
CP	CYCLOPENTANE
23DMB	2,3-DIMETHYLBUTANE
2MP	2-METHYLPENTANE
3MP	3-METHYLPENTANE
NHX	N-HEXANE
MCP	METHYLCYCLOPENTANE
22DMP	2,2-DIMETHYLPENTANE
24DMP	2,4-DIMETHYLPENTANE
223TMB	2,2,3-TRIMETHYLBUTANE
33DMP	3,3-DIMETHYLPENTANE
CHX	CYCLOHEXANE
23DMP	2,3-DIMETHYLPENTANE
2MHX	2-METHYLHEXANE
3MHX	3-METHYLHEXANE
UNK 3	UNKNOWN 3
3EP	3-ETHYLPENTANE
224TMP	2,2,4-TRIMETHYLPENTANE
NHP	N-HEPTANE
MCHX	METHYLCYCLOHEXANE
22DMHX	2,2-DIMETHYLHEXANE
223TMP	2,2,3-TRIMETHYLPENTANE
25DMHX	2,5-DIMETHYLHEXANE
24DMHX	2,4-DIMETHYLHEXANE
33DMHX	3,3-DIMETHYLHEXANE
234TMP	2,3,4-TRIMETHYLPENTANE
233TMP	2,3,3-TRIMETHYLPENTANE
23DMHX	2,3-DIMETHYLHEXANE
3MHP	3-METHYLHEPTANE
225TMHX	2,2,5-TRIMETHYLHEXANE
T12DMCHX	TRANS-1,2-DIMETHYLCYCLOHEXANE
NOC	N-OCTANE
C12DMCHX	CIS-1,2-DIMETHYLCYCLOHEXANE
NN	N-NONANE
ND	N-DECANE

ACETYLENES

---	ACETYLENE
MA	METHYLACETYLENE

AROMATICS

BZ	BENZENE
TOL	TOLUENE
EBZ	ETHYLBENZENE
PX	PARA-XYLENE
MX	META-XYLENE
OX	ORTHO-XYLENE
IPRBZ	I-PROPYLBENZENE
NPRBZ	N-PROPYLBENZENE
1M3EBZ	1-METHYL-3-ETHYLBENZENE
1M4EBZ	1-METHYL-4-ETHYLBENZENE
135TMBZ	1,3,5-TRIMETHYLBENZENE
1M2EBZ	1-METHYL-2-ETHYLBENZENE
TBBZ	TERT-BUTYLBENZENE
124TMBZ	1,2,4-TRIMETHYLBENZENE
IBBZ	I-BUTYLBENZENE
SBBZ	SEC-BUTYLBENZENE
1M3IPRBZ	1-METHYL-3-I-PROPYLBENZENE
123TMBZ	1,2,3-TRIMETHYLBENZENE
1M4IPRBZ	1-METHYL-4-I-PROPYLBENZENE
1M2IPRBZ	1-METHYL-2-I-PROPYLBENZENE

AROMATICS CONTINUED

13DEBZ	1,3-DIETHYLBENZENE
1M3NPRBZ	1-METHYL-3-N-PROPYLBENZENE
1M4NPRBZ	1-METHYL-4-N-PROPYLBENZENE
NBBZ	N-BUTYLBENZENE
12DEBZ	1,2-DIETHYLBENZENE
13DM5EBZ	1,3-DIMETHYL-5-ETHYLBENZENE
14DEBZ	1,4-DIETHYLBENZENE

OLEFINS

---	ETHYLENE
---	PROPYLENE
---	PROPADIENE
1B	1-BUTENE
IBE	I-BUTENE
13B	1,3-BUTADIENE
T2B	TRANS-2-BUTENE
C2B	CIS-2-BUTENE
UNK 1	UNKNOWN 1
3M1B	3-METHYL-1-BUTENE
1P	1-PENTENE
2M1B	2-METHYL-1-BUTENE
2M13B	2-METHYL-1,3-BUTADIENE
T2P	TRANS-2-PENTENE
C2P	CIS-2-PENTENE
2M2B	2-METHYL-2-BUTENE
T13P	TRANS-1,3-PENTADIENE
33DM1B	3,3-DIMETHYL-1-BUTENE
C13P	CIS-1,3-PENTADIENE
CPE	CYCLOPENTENE
4M1P	4-METHYL-1-PENTENE
23DM1B	2,3-DIMETHYL-1-BUTENE
4MC2P	4-METHYL-CIS-2-PENTENE
4MT2P	4-METHYL-TRANS-2-PENTENE
2M1P	2-METHYL-1-PENTENE
1HX	1-HEXENE
2E1B	2-ETHYL-1-BUTENE
C3HX	CIS-3-HEXENE
T3HX	TRANS-3-HEXENE
T2HX	TRANS-2-HEXENE
C2HX	CIS-2-HEXENE
2M2P	2-METHYL-2-PENTENE
3MT2P	3-METHYL-TRANS-2-PENTENE
3MC2P	3-METHYL-CIS-2-PENTENE
23DM2B	2,3-DIMETHYL-2-BUTENE
233TM1B	2,3,3-TRIMETHYL-1-BUTENE
34DM1P	3,4-DIMETHYL-1-PENTENE
5M1HX	5-METHYL-1-HEXENE
CHXE	CYCLOHEXENE
5MT2HX	5-METHYL-TRANS-2-HEXENE
34DMC2P	3,4-DIMETHYL-CIS-2-PENTENE
5MC2HX	5-METHYL-CIS-2-HEXENE
34DMT2P	3,4-DIMETHYL-TRANS-2-PENTENE
1HP	1-HEPTENE
T3HP	TRANS-3-HEPTENE
C3HP	CIS-3-HEPTENE
244TM1P	2,4,4-TRIMETHYL-1-PENTENE
3E2P	3-ETHYL-2-PENTENE
T2HP	TRANS-2-HEPTENE
C2HP	CIS-2-HEPTENE
244TM2P	2,4,4-TRIMETHYL-2-PENTENE
4MCHXE	4-METHYLCYCLOHEXENE
3MCHXE	3-METHYLCYCLOHEXENE
1MCHXE	1-METHYLCYCLOHEXENE
1OC	1-OCTENE
2E1HX	2-ETHYL-1-HEXENE
23DM2HX	2,3-DIMETHYL-2-HEXENE
T2OC	TRANS-2-OCTENE
26DM3HP	2,6-DIMETHYL-3-HEPTENE
C2OC	CIS-2-OCTENE

APPENDIX B

Table 1 - Typical Exhaust Hydrocarbon Analysis by Gas Chromatography and Calculation of Total Hydrocarbon Reactivity Index [1]

	A	B	C	D	E
PEAK	COMPONENT	CONCENTRATION PPMC	PPM	RELATIVE REACT.	REACT. INDEX
	PARAFFINS				
1	METHANE	130.03	130.03	0.00	0.00
2	ETHANE	34.31	17.16	0.42	7.21
6	PROPANE	0.00	0.00	0.66	0.00
8	IB	3.91	0.98	1.05	1.03
10	NB	41.24	10.31	1.27	13.09
16	IP	91.20	18.24	1.66	30.28
19	NP	39.13	7.83	1.58	12.37
25	22DMB	6.62	1.10	1.34	1.48
28	CP	3.01	0.60	1.56	0.94
29	23DMB	27.39	4.57	1.86	8.49
30	2MP	27.99	4.67	1.59	7.42
31	3MP	17.46	2.91	1.64	4.77
33	NHX	23.78	3.96	1.58	6.26
37	MCP 22DMP	12.04	1.85	1.90	3.52
38	24DMP 223TMB	22.27	3.18	1.30	4.14
40	33DMP CHX	5.72	0.88	1.50	1.32
42	23DMP 2MHX	27.99	4.00	1.50	6.00
43	3MHX UNK 3	9.33	1.33	1.50	2.00
44	3EP 224TMP	168.56	21.07	1.30	27.39
45	NHP	13.24	1.89	1.51	2.86
47	MCHX 22DMHX	6.02	0.80	1.60	1.28
48	UNK 5	0.00	0.00	1.50	0.00
49	223TMP 25DMHX 24DMHX	47.86	5.98	1.50	8.97
50	33DMHX 234TMP 233TMP 23DMHX	133.64	16.71	1.60	26.73
51	UNK 6	21.67	2.71	1.50	4.06
52	UNK 7	9.93	1.24	1.50	1.86
53	3MHP	6.02	0.75	1.63	1.23
54	225TMHX T12DMCHX	16.25	1.91	1.60	3.06
55	NOC	6.62	0.83	1.46	1.21
56	UNK 11	0.30	0.03	1.50	0.05
57	UNK 12	2.71	0.30	1.50	0.45
59	C12DMCHX	0.00	0.00	1.70	0.00
60	UNK 13	0.90	0.10	1.50	0.15
61	UNK 15	0.90	0.10	1.50	0.15
62	UNK 17	1.50	0.17	1.50	0.25
63	UNK 19	0.00	0.00	1.50	0.00
64	UNK 20	0.00	0.00	1.50	0.00
65	UNK 21	1.50	0.17	1.50	0.25
66	UNK 23	1.81	0.20	1.50	0.30
67	UNK 24	2.71	0.30	1.50	0.45
68	NN	1.81	0.20	1.42	0.28
70	UNK 26	0.30	0.03	1.50	0.05
71	UNK 28	0.00	0.00	1.50	0.00
72	UNK 30	0.00	0.00	1.50	0.00
74	UNK 31	0.00	0.00	1.50	0.00
75	UNK 32	0.00	0.00	1.50	0.00
76	UNK 33	1.20	0.12	1.50	0.18
79	ND	0.00	0.00	1.40	0.00
84	OTHER PARAFFINS	0.00	0.00	1.40	0.00
	SUB-TOTAL	968.92	269.22		191.53
	ACETYLENES				
4	ACETYLENE	157.72	78.86	0.00	0.00
7	MA WITH PROPADIENE	0.00	0.00	3.90	0.00
	SUB-TOTAL	157.72	78.86		0.00

(con't)

---

[1] Reprinted from M.W. Jackson, "Effects of Some Engine Variable and Control Systems On Composition and Reactivity of Exhaust Hydrocarbons", SAE transactions Vol. 75 (1967). SAE Publication # 660404.

APPENDIX B - CONTINUED

Table 1 (con't)

	A	B	C	D	E
PEAK	COMPONENT	CONCENTRATION PPMC	PPM	RELATIVE REACT.	REACT. INDEX
	AROMATICS				
39	BZ	99.33	16.55	0.56	9.27
50	TOL	633.30	90.47	2.20	199.04
63	EBZ	47.56	5.94	2.03	12.07
64	PX MX	90.30	11.29	4.92	55.53
66	OX	56.29	7.04	4.41	31.03
69	IPRBZ	2.71	0.30	1.64	0.49
72	NPRBZ	25.89	2.88	1.70	4.89
73	1M3EBZ 1M4EBZ	57.79	6.42	4.10	26.33
74	135TMBZ	20.47	2.27	8.64	19.65
75	1M2EBZ	28.29	3.14	3.60	11.32
77	TBBZ 124TMBZ	79.46	8.36	3.30	27.60
78	IBBZ SBBZ	5.12	0.51	1.00	0.51
79	1M3IPRBZ 123TMBZ	19.26	2.03	5.80	11.76
80	1M4IPRBZ	0.00	0.00	2.90	0.00
81	1M2IPRBZ	6.02	0.60	2.90	1.75
82	13DEBZ 1M3NPRBZ	28.29	2.83	4.20	11.88
83	1M4NPRBZ NBBZ 12DEBZ 13DM5EBZ 14DEBZ	19.56	1.96	3.40	6.65
84	OTHER AROMATICS	130.63	11.88	5.00	59.38
	SUB-TOTAL	1350.29	174.48		489.15
	OLEFINS				
3	ETHYLENE	204.68	102.34	2.88	294.74
5	PROPYLENE	176.99	59.00	5.93	349.85
7	PROPADIENE	30.10	10.03	3.90	39.13
9	1B IBE 13B	178.79	44.70	6.04	269.98
11	T2B	27.09	6.77	18.98	128.54
13	C2B	15.65	3.91	12.03	47.07
14	UNK 1	0.90	0.23	4.00	0.90
15	3M1B	6.02	1.20	4.58	5.51
17	1P	8.43	1.69	3.56	6.00
18	2M1B	24.08	4.82	5.76	27.74
20	2M13B	12.04	2.41	6.27	15.10
21	T2P	16.86	3.37	13.05	43.99
22	C2P	8.43	1.69	9.15	15.42
23	2M2B	38.53	7.71	32.20	248.12
24	T13P	0.00	0.00	6.80	0.00
25	33DM1B	3.01	0.50	3.56	1.79
26	C13P	0.00	0.00	6.80	0.00
27	CPE	3.01	0.60	38.98	23.47
28	4M1P	6.02	1.00	3.90	3.91
29	23DM1B	12.64	2.11	3.73	7.86
30	4MC2P 4MT2P	6.62	1.10	6.61	7.30
31	UNK 2	0.00	0.00	4.00	0.00
32	2M1P 1HX	6.02	1.00	3.39	3.40
33	2E1B	7.22	1.20	3.90	4.70
34	C3HX T3HX T2HX C2HX	7.22	1.20	8.40	10.11
35	2M2P	9.63	1.61	27.12	43.54
36	3MT2P	3.01	0.50	20.30	10.18
37	3MC2P	8.43	1.40	17.00	23.88
38	23DM2B 233TM1B	8.43	1.30	52.90	68.59
39	34DM1P	0.00	0.00	2.50	0.00
41	5M1HX	4.82	0.69	2.50	1.72
42	CHXE	10.23	1.71	5.93	10.11
43	5MT2HX 34DMC2P 5MC2HX 34DMT2P	21.67	3.10	11.00	34.06
44	1HP	45.75	6.54	2.54	16.60
45	T3HP C3HP	9.03	1.29	7.00	9.03
46	244TM1P 3E2P T2HP	6.02	0.82	9.40	7.72
47	C2HP UNK 4	4.21	0.60	5.90	3.55
49	244TM2P 4MCHXE 3MCHXE	13.24	1.81	13.00	23.49
51	1MCHXE	0.00	0.00	9.73	0.00
52	UNK 8	5.42	0.68	7.00	4.74
53	UNK 9	3.01	0.38	7.00	2.63
54	1OC 2E1HX UNK 10	10.23	1.28	2.80	3.58
55	23DM2HX T2OC	5.42	0.68	32.40	21.94
57	26DM3HP	0.60	0.07	6.80	0.45
58	C2OC	0.30	0.04	4.20	0.16
60	UNK 14	0.00	0.00	6.00	0.00
61	UNK 16	0.60	0.07	6.00	0.40
62	UNK 18	1.20	0.13	6.00	0.80
65	UNK 22	1.50	0.17	6.00	1.00
67	UNK 25	0.00	0.00	6.00	0.00
70	UNK 27	0.60	0.06	6.00	0.36
71	UNK 29	0.00	0.00	6.00	0.00
84	OTHER OLEFINS	0.00	0.00	6.00	0.00
	SUB-TOTAL	973.73	283.48		1843.19
	TOTAL	3450.67	806.04		2523.87

APPENDIX C

An Analysis Of The Two-Cycle Combustion Process

The two-stroke cycle engine was developed by Sir Dugald Clark in 1878. As the name implies, the basic difference between the two and the four cycle engine is the number of piston strokes required to complete one cycle of events. Referring to the illustrations (Figures 1 & 2) below, the two-cycle engine requires two strokes of the piston and one revolution of the crankshaft to complete one cycle of operation comprising intake, compression, power and exhaust, while the four cycle requires four strokes and two revolutions.

A diagrammatic cross section of a three-port, two-stroke engine is shown in Figure 3. "A" represents the crankcase inlet port, which is fully uncovered when the piston is at the outer end of its stroke. "B" is the transfer port, which is uncovered by the piston as it approaches the inner end of the stroke. In the drawing the piston is shown in the position where it begins to uncover the transfer port. An expansion stroke has just taken place, and the burnt gases are shown escaping through the exhaust port, which is partly uncovered by the piston before the latter begins to uncover the transfer port. During the interval between the beginning of exhaust-port opening and the beginning of transfer-port opening --- the blowdown period --- enough of the burnt gases in the combustion chamber must escape through the exhaust port to cause the pressure in the combustion chamber to drop to that in the crankcase. During the remainder of the in-stroke and the early part of the out-stroke, while both ports are open, the inflow of fresh charge under pressure through the transfer port blows some of the remaining burnt gases from the combustion chamber. This is known as the scavenging process. Naturally, there is some mixing of combustible mixture with burnt gases, and it is impossible in an engine of this type to completely scavenge the combustion chamber of burnt gases and to prevent loss of fresh charge through the exhaust port before the latter is closed. In order to prevent "short-circuiting" of the flow of gases through the engine as far as possible, the piston is provided with a deflector D opposite the transfer port, which is intended to deflect the incoming current of mixture upward on the side of the cylinder at which it enters, compelling it to pass down on the opposite side and sweep the burnt gases before it.

This type of scavenging is designated "loop" in order to distinguish it from the type of engine which does not have such a deflector and is called "cross-scavenged".

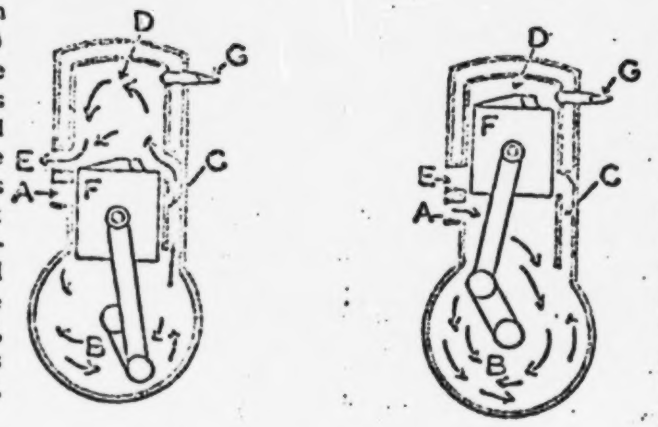
This short "circuiting" or loss of the fresh air-fuel mixture out of the the exhaust is the basic deficiency of the two-cycle engine, and the main reason why for a given displacement it does not develop twice as much power as a four-cycle engine. The other predominate reason is the poor scavenging of the burnt exhaust gases from the cylinder due to mixing with the fresh incoming air-fuel mixture.

In order to overcome this basic engine characteristic many attempts have been made to improve the scavenging efficiency of two-cycle engines, and hence their specific power output. Perhaps the best known of these is a separate pump or blower which is found on all two-cycle diesel engines. Other approaches have used rotary exhaust valves, conventional automotive type poppet valves, sleeve valves, reverse loop scavenging, opposed pistons and U-cylinders. All these means add cost and complexity of course, which to a greater or lesser degree detract from the main two-cycle engine attributes of low cost and simplicity.

If the basic scavenging process for a two-cycle engine is examined from the standpoint of predicting exhaust emissions it is apparent that in all probability the emissions will be high for the same reason that the average BMEP (Brake Mean Effective Pressure) and consequent power output is low --- poor cylinder scavenging. In the ideal scavenging process the fresh incoming air-fuel mixture would push the residual gases before it without mixing or exchanging heat with them, and this process would continue until all the burned gases had been replaced with fresh mixture, at which point the flow would cease. In this idealized scavenging process not only is the cylinder filled with fresh mixture, but also no fresh mixture escapes from the exhaust ports. However, in actual engines of course, the fresh mixture actually does mix and exchange heat with the residual gases during the scavenging process and some portion of the fresh mixture is lost through the exhaust ports. The amount of fresh mixture loss to the exhaust will vary primarily with the efficiency of the scavenging process, and hence for a given operating condition will be a function of specific engine design.

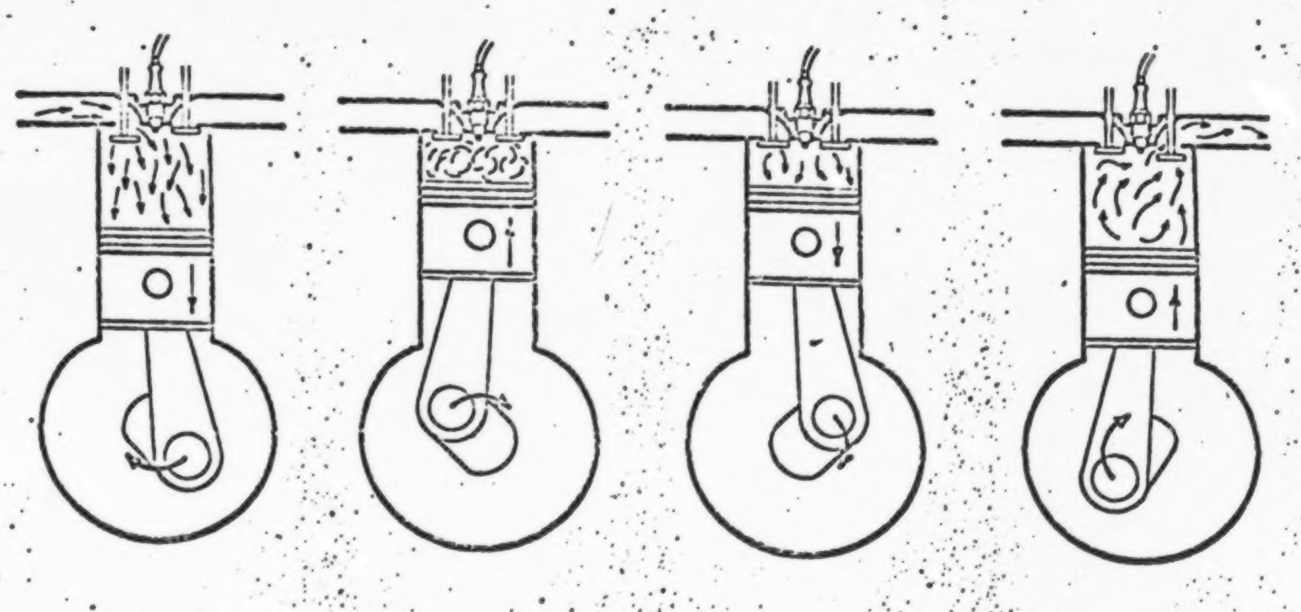
This loss of carburetted mixture through the exhaust port is believed to be prima facie evidence that the exhaust emissions in terms of concentration of hydrocarbons and partially-oxidized hydrocarbons for a two-cycle engine is of a significantly higher order than emissions from a four-cycle engine.

The resulting combustion pressure forces the piston downward (power stroke) furnishing power to turn the propeller. As piston descends it closes intake port "A" and compresses mixture charge in the crankcase. Towards the end of the stroke exhaust port "E" is opened; then by-pass port "C" is opened which permits new mixture to flow into cylinder "D", displacing the burned gases through exhaust port "E".



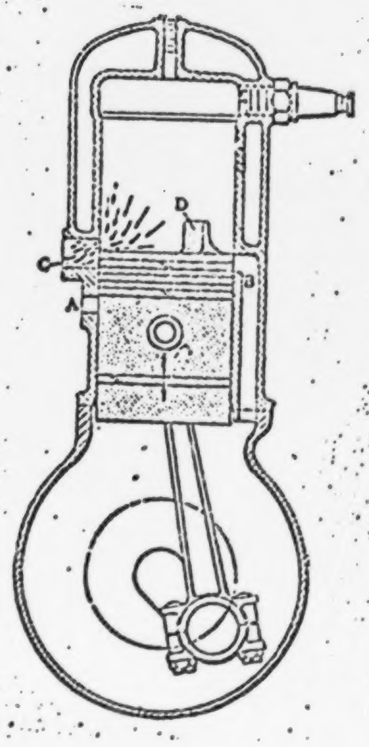
Upward (compression) stroke compresses mixture in cylinder "D" in preparation for ignition. Simultaneously, it creates a partial vacuum in the crankcase so that, as intake port "A" is uncovered fuel-oil-air mixture for a new charge flows in from the carburetor. At the end of the upward (compression) stroke, spark plug "G" ignites the compressed mixture.

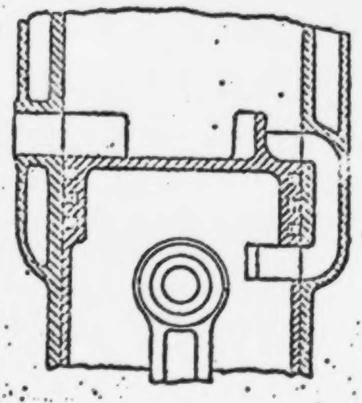
The Operating Principle Of The
Two-Stroke Gasoline Engine



Intake Compression Power Exhaust

The Operating Principle Of The
Four-Stroke Gasoline Engine





Transfer Port
Detail

Three-Port type of
Two-stroke engine

CHAPTER II YAMAHA AUTOLUVE

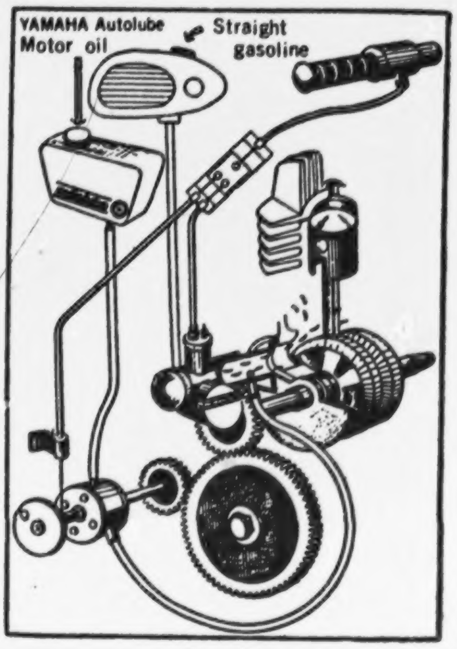
A. WHAT IS YAMAHA AUTOLUBE?

Yamaha Autolube is an automatic engine lubrication system based on a revolutionary "separate lubrication" principle, which outmodes the conventional 2-stroke pre-mixed system.

B. FEATURES OF YAMAHA AUTOLUBE:

1. The oil pump is driven by the engine through a reduction gear, and is connected to the throttle valve of the carburetor which is controlled by the accelerator grip.

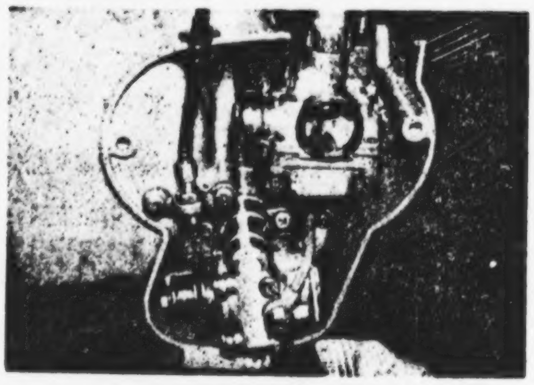
2. Lubricating oil is fed to the engine after being automatically metered in proportion to engine rpm and throttle opening. Thus the engine provides and regulates its own lubrication.



2—1

3. Yamaha Autolube eliminates lubrication problems peculiar to 2-stroke engines with the conventional "pre-mix" system, and improves many inherent advantages of 2-stroke design. (Fig. 2-1 & 2)

a. Autolube supplies only the flow of engine lubricant the engine needs for its specific operating condition, allowing:
   1) Savings in oil consumption.
   2) Decreased carbon accumulation.
   3) Decreased exhaust smoke, and
   4) More effective engine lubrication.



2—2

APPENDIX E

Calibration of Constant Mass Sampler (CMS):

Before the system can be used to measure exhaust, the Roots blower must be calibrated. This can be done by the following procedure.

1. Operate system until equilibrium temperatures are reached.

2. Introduce pure propane (99.5 +) by means of a wet test meter or other accurate flow measuring device into the inlet of the heat exchanger.

   Note: If a wet test meter is used, the propane should be preconditioned by passing it through a water bubbler. Also in the final calibration a water vapor correction must be made.

3. Measure concentration of propane at inlet to large Roots blower, using NDIR analyzer of FID that has been accurately calibrated with propane calibration gases.

4. Repeat at different propane flow rates until several data are obtained.

5. Plot propane flow rate as concentration. A straight line which passes through the origin should be obtained.

6. Calculate flow rate using perfect gas laws (PV = nRT) and the following formula.

APPENDIX E - Cont'd

Blower flow rate, CFM =

$$\frac{\text{Pure Propane flow rate, (CFM X } 10^6\text{)}}{\text{measured Propane concentration (PPM)}}$$

7. Example of Calculations:

a. Assume: 300 liters/hour C_3H_8 introduced 650 PPM C_3H_8 measured

Then:

$$\frac{\text{liters}}{\text{hour}} \text{ X } \frac{\text{hours}}{\text{60 min/hr.}} \text{ X } \frac{\text{ft}^3}{\text{28.32 liters/ft}^3} = \text{ft}^3\text{/min.}$$

$$\frac{\text{ft}^3}{\text{min.}} \text{ X } \frac{1 \text{ X } 10^6}{\text{PPM}} = \text{ft}^3\text{/min.}$$

$$300 \text{ X } \frac{1}{60} \text{ X } \frac{1}{28.32} = 0.1765 \text{ ft}^3\text{/min.}$$

$$0.1765 \text{ X } \frac{1{,}000{,}000}{650} = 272.0 \text{ ft/min.}$$

b. Make correction for H_2O vapor present at ambient temperature e.g., Temp = 21.8° C, Vapor H_2O = 19.7 mm Hg. Barometer = 760 mm

Then: 760 - 19.7 = 740.3 mm Hg.

$$\frac{740.3}{760} \text{ X } 272 \text{ ft}^3\text{/min.} = 264 \text{ ft}^3\text{/min. dry air.}$$

c. Determine density of air at ambient temperature and pressure.

APPENDIX E - Cont'd

d. Then: Lbs/ft^3 X ft^3/min. = Pounds/minute of air.

e. Knowing number of pump revolutions and time determine revolutions per minute (rev/min).

f. Then: $\frac{\text{Lbs.}}{\text{min}} \times \frac{\text{min.}}{\text{rev.}} = \frac{\text{Lbs.}}{\text{rev.}}$

g. $\frac{\text{Lbs}}{\text{rev.}} \times \frac{\text{rev.}}{1}$ = Pounds, etc.

TEST OLSON LAB SAMPLE NO 1   YAMAHA 250

PARAFFINS

A

PEAK	NAME	PPMC	PCT	CARBON
1	METHANE	1067.59	2.41	1.00
2	ETHANE	100.32	0.23	2.00
6	PROPANE	15.05	0.03	3.00
8	IB	173.77	0.39	4.00
10	NB 22DMPR	2052.34	4.63	4.50
16	IP	3003.04	6.78	5.00
19	NP	1840.98	4.16	5.00
25	22DMB	78.70	0.18	6.00
28	CP	177.51	0.40	5.00
29	23DMB	492.02	1.11	6.00
30	2MP	1695.80	3.83	6.00
31	3MP	1114.27	2.51	6.00
33	NHX	1354.12	3.06	6.00
37	MCP 22DMP	958.18	2.16	6.50
38	24DMP 223TMB	604.87	1.37	7.00
40	33DMP CHX	394.22	0.89	6.50
42	23DMP 2MHX	1735.51	3.92	7.00
43	3MHX UNK 4	1074.66	2.43	7.00
431	UNK 4A	0.0	0.0	7.00
432	UNK 4B	246.01	0.56	7.00
433	UNK 4C	260.26	0.59	7.00
44	3EP 224TMP	824.82	1.86	8.00
45	NHP	883.82	1.99	7.00
47	MCHX 22DMHX	710.45	1.60	7.50
471	UNK 4D	104.26	0.24	8.00
48	UNK 5	134.27	0.30	8.00
49	223TMP 25DMHX 24DMHX	431.70	0.97	8.00
491	UNK 5B	10.10	0.02	8.00
492	UNK 5C	29.60	0.07	8.00
50	33DMHX 234TMP 233TMP 23DMHX	616.89	1.39	8.00
51	UNK 6	137.81	0.31	8.00
52	UNK 7	671.25	1.51	8.00
53	3MHP	449.59	1.01	8.00
54	225TMHX T12DMCHX	196.30	0.44	8.00
541	UNK 9A	42.84	0.10	8.00
542	UNK 9B	25.46	0.06	5.00
55	NOC	454.94	1.03	8.00
56	UNK 10	0.0	0.0	9.00
57	UNK 11	12.83	0.03	9.00
59	C12DMCHX	58.29	0.13	8.00
60	UNK 12	58.40	0.13	9.00
61	UNK 13	112.35	0.25	9.00
62	UNK 15	69.11	0.16	9.00
63	UNK 17	17.78	0.04	9.00
64	UNK 18	46.17	0.10	9.00
65	UNK 19	145.99	0.33	9.00
651	UNK 19A	95.17	0.21	9.00
652	UNK 19B	0.0	0.0	9.00
66	UNK 20	0.0	0.0	9.00
67	UNK 21	43.04	0.10	9.00
68	UNK 22	5.56	0.01	9.00
69	NN	190.14	0.43	9.00
70	UNK 25	50.41	0.11	10.00
71	UNK 26	4.04	0.01	10.00
72	UNK 28	3.64	0.01	10.00
73	UNK 30	7.07	0.02	10.00
74	UNK 31	0.0	0.0	10.00
75	UNK 32	0.81	0.00	10.00
76	UNK 33	39.40	0.09	10.00
77	UNK 34	15.36	0.03	10.00

PARAFFINS

B

PPMC	PCT	CARBON NO	PPM	PCT	REAC. NO.	REACT	PCT
1067.59	2.41	1.00	1067.59	12.03	0.0	0.0	0.0
100.32	0.23	2.00	50.16	0.57	0.42	21.07	0.08
15.05	0.03	3.00	5.02	0.06	0.66	3.31	0.01
173.77	0.39	4.00	43.44	0.49	1.05	45.62	0.17
2052.34	4.63	4.50	456.08	5.14	1.27	579.22	2.17
3003.04	6.78	5.00	600.61	6.77	1.66	997.01	3.73
1840.98	4.16	5.00	368.20	4.15	1.58	581.75	2.18
78.70	0.18	6.00	13.12	0.15	1.34	17.58	0.07
177.51	0.40	5.00	35.50	0.40	1.56	55.38	0.21
497.02	1.11	6.00	82.00	0.92	1.86	152.53	0.57
1695.80	3.83	6.00	282.63	3.19	1.59	449.39	1.68
1114.27	2.51	6.00	185.71	2.09	1.64	304.57	1.14
1354.12	3.06	6.00	225.69	2.54	1.58	356.59	1.33
958.18	2.16	6.50	147.41	1.66	1.90	280.08	1.05
604.87	1.37	7.00	86.41	0.97	1.30	112.33	0.42
394.22	0.89	6.50	60.65	0.68	1.50	90.97	0.34
1735.51	3.92	7.00	247.93	2.79	1.50	371.89	1.39
1074.66	2.43	7.00	153.52	1.73	1.50	230.29	0.86
0.0	0.0	7.00	0.0	0.0	1.50	0.0	0.0
246.01	0.56	7.00	35.14	0.40	1.50	52.72	0.20
260.26	0.59	7.00	37.18	0.42	1.50	55.77	0.21
824.82	1.86	8.00	103.10	1.16	1.30	134.03	0.50
883.82	1.99	7.00	126.26	1.42	1.51	190.65	0.71
710.45	1.60	7.50	94.73	1.07	1.60	151.56	0.57
104.26	0.24	8.00	13.03	0.15	1.50	19.55	0.07
134.27	0.30	8.00	16.78	0.19	1.50	25.18	0.09
431.70	0.97	8.00	53.96	0.61	1.50	80.94	0.30
10.10	0.02	8.00	1.25	0.01	1.50	1.89	0.01
29.60	0.07	8.00	3.70	0.04	1.50	5.55	0.02
616.89	1.39	8.00	77.11	0.87	1.60	123.38	0.46
137.81	0.31	8.00	17.23	0.19	1.50	25.84	0.10
671.25	1.51	8.00	83.91	0.95	1.50	125.86	0.47
449.59	1.01	8.00	56.20	0.63	1.63	91.60	0.34
196.30	0.44	8.00	24.54	0.28	1.60	39.26	0.15
42.84	0.10	8.00	5.35	0.06	1.50	8.03	0.03
25.46	0.06	8.00	3.18	0.04	1.50	4.77	0.02
454.94	1.03	8.00	56.87	0.64	1.46	83.03	0.31
0.0	0.0	9.00	0.0	0.0	1.50	0.0	0.0
12.83	0.03	9.00	1.43	0.02	1.50	2.14	0.01
58.29	0.13	8.00	7.29	0.08	1.70	12.39	0.05
58.40	0.13	9.00	6.49	0.07	1.50	9.73	0.04
112.35	0.25	9.00	12.48	0.14	1.50	18.72	0.07
69.11	0.16	9.00	7.68	0.09	1.50	11.52	0.04
17.78	0.04	9.00	1.98	0.02	1.50	2.96	0.01
46.17	0.10	9.00	5.13	0.06	1.50	7.70	0.03
145.99	0.33	9.00	16.22	0.18	1.50	24.33	0.09
95.17	0.21	9.00	10.57	0.12	1.50	15.86	0.06
0.0	0.0	9.00	0.0	0.0	1.50	0.0	0.0
0.0	0.0	9.00	0.0	0.0	1.50	0.0	0.0
43.04	0.10	9.00	4.78	0.05	1.50	7.17	0.03
5.56	0.01	9.00	0.62	0.01	1.50	0.93	0.00
190.14	0.43	9.00	21.13	0.24	1.42	30.00	0.11
50.41	0.11	10.00	5.04	0.06	1.50	7.56	0.03
4.04	0.01	10.00	0.40	0.00	1.50	0.61	0.00
3.64	0.01	10.00	0.36	0.00	1.50	0.55	0.00
7.07	0.02	10.00	0.71	0.01	1.50	1.06	0.00
0.0	0.0	10.00	0.0	0.0	1.50	0.0	0.0
0.81	0.00	10.00	0.08	0.00	1.50	0.12	0.00
39.40	0.09	10.00	3.94	0.04	1.50	5.91	0.02
15.36	0.03	10.00	1.54	0.02	1.50	2.30	0.01

```
 67  UNK 21                                          43.04   0.1
 68  UNK 22                                           5.56   0.01
 69  NN                                             190.14   0.43
 70  UNK 25                                          50.41   0.11
 71  UNK 26                                           4.04   0.01
 72  UNK 28                                           3.64   0.01

 73  UNK 30                                           7.07   0.02
 74  UNK 31                                           0.0    0.0
 75  UNK 32                                           0.81   0.00
 76  UNK 33                                          39.40   0.09
 77  UNK 34                                          15.36   0.03

 78  UNK 35                                           0.0    0.0
 79  ND                                              88.50   0.20
 80  UNK 37                                           7.58   0.02
 81  UNK 38                                           0.0    0.0
 82  UNK 39                                           0.0    0.0

 83  UNK 40                                           0.0    0.0
 84  UNK 41                                           0.0    0.0
 85  OTHER PARAFFINS                                  5.05   0.01

         TOTAL                                    25239.91 56.97
         AVERAGE
```

C

Ayl

TEST OLSON LAB SAMPLE NO 1   YAMAHA 250

9266

TEST OLSON LAB SAMPLE NO 1   YAMAHA 250

```
                                                          OLEFI
PEAK                  NAME
                                                    PPMC    PCT

  3  ETHYLENE                                      1414.03  3.1
```

```
4   0.10     9.00        4.78   0.05      1.50    7.17   0.03

6   0.01     9.00        0.67   0.01      1.50    0.93   0.00
4   0.43     9.00       21.13   0.24      1.42   30.00   0.11
1   0.11    10.00        5.04   0.06      1.50    7.56   0.03
4   0.01    10.00        0.40   0.00      1.50    0.61   0.00
4   0.01    10.00        0.36   0.00      1.50    0.55   0.00

7   0.02    10.00        0.71   0.01      1.50    1.06   0.00
    0.0     10.00        0.0    0.0       1.50    0.0    0.0
1   0.00    10.00        0.08   0.00      1.50    0.12   0.00
0   0.09    10.00        3.94   0.04      1.50    5.91   0.02
6   0.03    10.00        1.54   0.02      1.50    2.30   0.01

    0.0     10.00        0.0    0.0       1.50    0.0    0.0
0   0.20    10.00        8.85   0.10      1.40   12.39   0.05
8   0.02    11.00        0.69   0.01      1.50    1.03   0.00
    0.0     11.00        0.0    0.0       1.50    0.0    0.0
    0.0     11.00        0.0    0.0       1.50    0.0    0.0

    0.0     11.00        0.0    0.0       1.50    0.0    0.0
    0.0     11.00        0.0    0.0       1.50    0.0    0.0
5   0.01    11.50        0.44   0.00      1.50    0.66   0.00

1 56.97               5038.97  56.79           6044.73  22.61
             5.01                         1.20
```

Avg C No

AvgR:1,

D

```
    OLEFINS

C   PCT   CARBON NO    PPM     PCT    REAC. NO.   REACT    PCT
```

E

```
TEST OLSON LAB SAMPLE NO 1   YAMAHA 250

PEAK                    NAME
                                                          PP

   3  ETHYLENE
   5  PROPYLENE                                         1414.
   7  PROPADIENE                                         801.
   9  1B IBE 13B                                          21.
  11  T2B                                                725.
                                                         243.
  12  UNK 1
  13  C2B                                                 46.
  14  UNK 1A2                                            126.
  15  3M1B                                                 1.
  17  1P                                                  73.
                                                         152.
  18  2M1B
  20  2M13B                                              237.1
  21  T2P                                                112.5
  22  C2P                                                238.2
  23  2M2B                                               119.1
                                                         359.5
  24  T13P
  25  UNK 2                                               55.3
  26  C13P                                                 9.3
  27  CPE                                                  0.0
  28  4M1P                                                62.5
                                                          72.7
  29  23DM1B
 291  UNK 2A2                                             51.5
  30  4MT2P                                                0.0
 301  4MC2P                                              116.4
  31  UNK 3                                                0.0
                                                           0.0
  32  2M1P 1HX
  33  2E1B                                               239.72
  34  C3HX T3HX T2HX                                      13.28
  35  2M2P 3MT2P                                         267.18
  36  23DM13B C2HX                                       208.44
                                                          50.76
  37  3MC2P
 371  UNK 3A2                                            135.51
  38  23DM2B 233TM1B                                       0.0
 381  UNK 3B2                                             47.72
  39  1MCPE 34DM1P                                        15.53
                                                           0.0
  41  5M1HX
 411  UNK 3C2                                             81.82
  42  CHXE                                                16.66
  43  5MT2HX 34DMC2P 5MC2HX 34DMT2P                      137.53
 431  UNK 4A2                                             39.50
                                                           0.0
 432  UNK 4B2
 433  UNK 4C2                                              0.0
  44  2M1HX 1HP                                           15.53
 441  UNK 4D2                                            111.65
  45  2M2HX T3HP C3HP                                     75.29
                                                         132.47
 451  UNK 4E2
  46  244TM1P 3E2P T2HP                                    0.0
 461  UNK 4F2                                            107.48
  47  23DM2P C2HP                                          0.0
 471  UNK 4G2                                            129.32
                                                           0.0
  48  UNK 5A2
  49  244TM2P 4MCHXE 3MCHXE                               73.04
 491  UNK 5B2                                             22.51
 OLEFINS

 PCT    CARBON NO     PPM      PCT    REAC. NO.  REACT     PCT

3.19      2.00      707.01     7.97      2.89 2036.20     7.62
1.81      3.00      267.11     3.01      5.93 1583.96     5.92
0.05      3.00        7.07     0.08      3.90   27.36     0.10
1.54      4.00      181.28     2.04      6.04 1094.95     4.10
0.55      4.00       60.83     0.69     18.98 1154.57     4.32

0.11      4.00       11.73     0.13     15.00  175.99     0.66
0.29      4.00       31.68     0.36     12.03  381.13     1.43
0.00      4.00        0.37     0.00      4.00    1.46     0.01
0.17      5.00       14.72     0.17      4.58   67.42     0.25
0.34      5.00       30.48     0.34      3.56  108.50     0.41

0.54      5.00       47.43     0.53      5.76  273.18     1.02
0.25      5.00       22.51     0.25      6.27  141.13     0.53
0.54      5.00       47.65     0.54     13.05  621.86     2.33
0.27      5.00       23.84     0.27      9.15  218.11     0.82
0.81      5.00       71.92     0.81     32.20 2315.72     8.66

0.12      5.00       11.07     0.12      6.80   75.31     0.28
0.02      5.00        1.87     0.02      4.00    7.47     0.03
0.0       5.00        0.0      0.0       6.80    0.0      0.0
0.14      5.00       12.52     0.14     38.98  487.84     1.82
0.16      6.00       12.12     0.14      3.90   47.26     0.18

0.12      6.00        8.59     0.10      3.73   32.04     0.12
0.0       6.00        0.0      0.0       4.00    0.0      0.0
0.26      6.00       19.41     0.22      6.61  128.33     0.48
0.0       6.00        0.0      0.0       6.50    0.0      0.0
0.0       6.00        0.0      0.0       4.00    0.0      0.0

0.54      6.00       39.95     0.45      3.39  135.44     0.51
0.03      6.00        2.21     0.02      3.90    8.63     0.03
0.60      6.00       44.53     0.50      8.40  374.06     1.40
0.47      6.00       34.74     0.39     27.12  942.13     3.52
0.11      6.00        8.46     0.10     20.30  171.73     0.64

0.31      6.00       22.58     0.25     17.00  383.93     1.44
0.0       6.00        0.0      0.0      25.00    0.0      0.0
0.11      6.50        7.34     0.08     52.90  388.36     1.45
0.04      7.00        2.22     0.03     25.00   55.47     0.21
0.0       6.50        0.0      0.0      25.00    0.0      0.0

0.18      7.00       11.69     0.13      2.50   29.22     0.11
0.04      7.00        2.38     0.03      2.50    5.95     0.02
0.31      6.00       22.92     0.26      5.93  135.93     0.51
0.09      7.00        5.64     0.06     11.00   62.08     0.23
0.0       7.00        0.0      0.0      10.00    0.0      0.0

0.0       7.00        0.0      0.0      10.00    0.0      0.0
0.04      7.00        2.22     0.03     10.00   22.19     0.08
0.25      7.00       15.95     0.18      2.80   44.66     0.17
0.17      7.00       10.76     0.12      7.00   75.29     0.28
0.30      7.00       18.92     0.21     11.30  213.84     0.80

0.0       7.00        0.0      0.0      10.00    0.0      0.0
0.24      7.33       14.66     0.17      9.40  137.83     0.52
0.0       7.00        0.0      0.0      10.00    0.0      0.0
0.29      7.00       18.47     0.21     47.00  868.26     3.25
0.0       7.00        0.0      0.0      30.00    0.0      0.0

0.16      7.00       10.43     0.12     30.00  313.04     1.17
0.05      7.33        3.07     0.03     13.00   39.92     0.15
0.0       7.33        0.0      0.0      13.00    0.0      0.0
0.0       7.33        0.0      0.0      13.00    0.0      0.0
0.08      7.00        4.79     0.05      9.73   46.62     0.17

0.0       8.00        0.0      0.0       7.00    0.0      0.0
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F

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291  UNK 2A2                                   51.55   0.12     6.00
 30  4MT2P                                      0.0    0.0      6.00
301  4MC2P                                    116.49   0.26     6.00
 31  UNK 3                                      0.0    0.0      6.00
                                                0.0    0.0      6.00

 32  2M1P 1HX
 33  2E1B                                     239.72   0.54     6.00
 34  C3HX T3HX T2HX                            13.28   0.03     6.00
 35  2M2P 3MT2P                               267.18   0.60     6.00
 36  23DM13B C2HX                             208.44   0.47     6.00
                                               50.76   0.11     6.00

 37  3MC2P
371  UNK 3A2                                  135.51   0.31     6.00
 38  23DM2B 233TM1B                             0.0    0.0      6.00
381  UNK 3B2                                   47.72   0.11     6.50
 39  1MCPE 34DM1P                              15.53   0.04     7.00
                                                0.0    0.0      6.50

 41  5M1HX
411  UNK 3C2                                   81.82   0.18     7.00
 42  CHXE                                      16.66   0.04     7.00
 43  5MT2HX 34DMC2P 5MC2HX 34DMT2P            137.53   0.31     6.00
431  UNK 4A2                                   39.50   0.09     7.00
                                                0.0    0.0      7.00

432  UNK 4B2
433  UNK 4C2                                    0.0    0.0      7.00
 44  2M1HX 1HP                                 15.53   0.04     7.00
441  UNK 4D2                                  111.65   0.25     7.00
 45  2M2HX T3HP C3HP                           75.29   0.17     7.00
                                              132.47   0.30     7.00

451  UNK 4E2
 46  244TM1P 3E2P T2HP                          0.0    0.0      7.00
461  UNK 4F2                                  107.48   0.24     7.33
 47  23DM2P C2HP                                0.0    0.0      7.00
471  UNK 4G2                                  129.32   0.29     7.00
                                                0.0    0.0      7.00

 48  UNK 5A2
 49  244TM2P 4MCHXE 3MCHXE                     73.04   0.16     7.00
491  UNK 5B2                                   22.51   0.05     7.33
492  UNK 5C2                                    0.0    0.0      7.33
 51  1MCHXE                                     0.0    0.0      7.33
                                               33.54   0.08     7.00

 52  UNK 8
 53  UNK 9                                      0.0    0.0      8.00
 54  10C 2E1HX                                230.94   0.52     8.00
541  UNK 9A2                                  102.53   0.23     8.00
542  UNK 9B2                                   71.58   0.16     8.00
                                               72.25   0.16     8.00

 55  23DM2HX T40C 2M2HP
 56  UNK 9C2                                   88.35   0.20     8.00
 57  26DM3HP                                    0.0    0.0      8.00
 58  T20C C20C                                 84.41   0.19     9.00
 60  4EECHXE                                    0.0    0.0      8.00
                                               18.23   0.04     8.00

601  UNK 13A2
 61  UNK 14                                     0.0    0.0      8.00
611  UNK 14A2                                  16.99   0.04     9.00
 62  UNK 16                                     0.0    0.0      9.00
621  UNK 16A2                                  63.59   0.14     9.00
                                                0.0    0.0      9.00

631  UNK 17A2
 65  12DMCHXE                                   0.0    0.0      9.00
651  UNK 19A2                                 165.68   0.38     8.00
 67  UNK 21A2                                   0.0    0.0      9.00
 68  UNK 23                                    98.70   0.22     9.00
                                               72.14   0.16     9.00

 69  UNK 24
691  UNK 24A2                                 180.75   0.41     9.00
 71  UNK 27                                     0.0    0.0     10.00
711  UNK 27A2                                  41.98   0.09    10.00
 72  UNK 29                                     0.0    0.0     10.00
                                               74.51   0.17    10.00

721  UNK 29A2
741  UNK 31A2                                  18.46   0.04    10.00
 85  OTHER OLEFINS                              0.0    0.0     10.00
                                                0.0    0.0     11.00

     TOTAL
     AVERAGE                                 8397.21  18.95

                                                                4.08
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G

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0.0         6.00        0.0     0.0          4.00      0.0      0.0
0.26        6.00       19.41    0.22         6.61    128.33     0.48
0.0         6.00        0.0     0.0          6.50      0.0      0.0
0.0         6.00        0.0     0.0          4.00      0.0      0.0

0.54        6.00       39.95    0.45         3.39    135.44     0.51
0.03        6.00        2.21    0.02         3.70      8.63     0.03
0.60        6.00       44.53    0.50         8.40    374.06     1.40
0.47        6.00       34.74    0.39        27.12    942.13     3.52
0.11        6.00        8.46    0.10        20.30    171.73     0.64

0.31        6.00       22.58    0.25        17.00    383.93     1.44
0.0         6.00        0.0     0.0         25.00      0.0      0.0
0.11        6.50        7.34    0.08        52.90    388.36     1.45
0.04        7.00        2.22    0.03        25.00     55.47     0.21
0.0         6.50        0.0     0.0         25.00      0.0      0.0

0.18        7.00       11.69    0.13         2.50     29.22     0.11
0.04        7.00        2.38    0.03         2.50      5.95     0.02
0.31        6.00       22.92    0.26         5.93    135.93     0.51
0.09        7.00        5.64    0.06        11.00     62.08     0.23
0.0         7.00        0.0     0.0         10.00      0.0      0.0

0.0         7.00        0.0     0.0         10.00      0.0      0.0
0.04        7.00        2.22    0.03        10.00     22.19     0.08
0.25        7.00       15.35    0.18         2.80     44.66     0.17
0.17        7.00       10.76    0.12         7.00     75.29     0.28
0.30        7.00       18.92    0.21        11.30    213.84     0.80

0.0         7.00        0.0     0.0         10.00      0.0      0.0
0.24        7.33       14.66    0.17         9.40    137.83     0.52
0.0         7.00        0.0     0.0         10.00      0.0      0.0
0.29        7.00       18.47    0.21        47.00    868.26     3.25
0.0         7.00        0.0     0.0         30.00      0.0      0.0

0.16        7.00       10.43    0.12        30.00    313.04     1.17
0.05        7.33        3.07    0.03        13.00     39.92     0.15
0.0         7.33        0.0     0.0         13.00      0.0      0.0
0.0         7.33        0.0     0.0         13.00      0.0      0.0
0.08        7.00        4.79    0.05         9.73     46.62     0.17

0.0         8.00        0.0     0.0          7.00      0.0      0.0
0.52        8.00       28.87    0.33         7.00    202.08     0.76
0.23        8.00       12.82    0.14         2.80     35.89     0.13
0.16        8.00        8.95    0.10         2.50     22.37     0.08
0.16        8.00        9.03    0.10         2.50     22.58     0.08

0.20        8.00       11.04    0.12        27.85    307.57     1.15
0.0         8.00        0.0     0.0          7.00      0.0      0.0
0.19        9.00        9.49    0.11         6.89     63.78     0.24
0.0         9.00        0.0     0.0          4.90      0.0      0.0
0.04        8.00        2.28    0.03         3.05      6.95     0.03

0.0         8.00        0.0     0.0          6.00      0.0      0.0
0.04        9.00        1.83    0.02         6.00     11.33     0.04
0.0         9.00        0.0     0.0          6.00      0.0      0.0
0.14        9.00        7.07    0.08         6.00     42.39     0.16
0.0         9.00        0.0     0.0          6.00      0.0      0.0

0.0         9.00        0.0     0.0          6.00      0.0      0.0
0.38        8.00       20.84    0.23        15.42    321.28     1.20
0.0         9.00        0.0     0.0          6.00      0.0      0.0
0.22        9.00       10.37    0.12         6.00     65.80     0.25
0.16        9.00        8.02    0.09         6.00     48.09     0.18

0.41        9.00       20.08    0.23         6.00    120.50     0.45
0.0        10.00        0.0     0.0          6.00      0.0      0.0
0.09       10.00        4.20    0.05         6.00     25.19     0.09
0.0        10.00        0.0     0.0          6.00      0.0      0.0
0.17       10.00        7.45    0.08         6.00     44.70     0.17

0.04       10.00        1.85    0.02         6.00     11.07     0.04
0.0        10.00        0.0     0.0          6.00      0.0      0.0
0.0        11.00        0.0     0.0          6.00      0.0      0.0

.95                  2059.82   23.21                ********   62.78
            4.08                             8.15
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~~1678.59~~

16285.9

H

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TEST  OLSON LAB SAMPLE NO 1   YAMAHA 250
                                                                   AROMATICS
PEAK                          NAME
                                                         PPMC     PCT    CARBON NO    PP

 39  BZ
 50  TOL                                               964.26   2.18      6.00      160.
 63  EBZ                                              2310.61   5.21      7.00      330.
 64  PX MX                                             518.88   1.17      8.00       64.
652  PHEE (STYRENE)                                   2033.11   4.59      8.00      254.
                                                         0.0    0.0       8.00        0.
 66  OX
 70  IPRBZ                                             941.72   2.13      8.00      117.
 73  NPRBZ                                               3.19   0.01      9.00        0.
 74  1M3EBZ 1M4EBZ                                     184.35   0.42      9.00       20.
 75  135TMBZ                                           703.23   1.59      9.00       78.
I                                                      294.08   0.66      9.00       32.
751  UNK 32A3
 76  1M2EBZ 2PH1PR                                       0.0    0.0      10.00        0.
761  UNK 33A3                                          333.09   0.75      9.00       37.
 77  C1PH1PR TBBZ 124TMBZ                               56.20   0.13     10.00        5.
 78  IBBZ SBBZ                                         799.47   1.80      9.33       85.
                                                        25.32   0.06     10.00        2.
 79  UNK 36
 80  1M3IPRBZ 123TMBZ                                   24.70   0.06      9.50        2.
 81  1M4IPRBZ T1PH1PR                                  112.20   0.25      9.50       11.
 82  1M2IPRBZ                                           63.61   0.14      9.50        6.
 83  13DEBZ 1M3NPRBZ                                    23.06   0.05     10.00        2.3
                                                       122.90   0.28     10.00       12.2
 84  1M4NPRBZ NBBZ 12DEBZ 13DM5EBZ 14DEBZ
 85  OTHER AROMATICS                                    65.77   0.15     10.00        6.5
                                                         0.0    0.0      11.00        0.0
        TOTAL
        AVERAGE                                       9579.73 21.62                1232.2
                                                                          7.77

                                                                   ACETYLENES
PEAK                          NAME
                                                         PPMC     PCT    CARBON NO    PPM

  4  ACETYLENE
107  MA                                               1072.43   2.42      2.00      536.2
 13  EA WITH C2B                                        17.91   0.04      3.00        5.9
                                                         0.0    0.0       4.00        0.0
        TOTAL
        AVERAGE                                       1090.34   2.46                 542.1
                                                                          2.01


        GRAND TOTALS
                                                         PPMC                          PPM
                                                       ********* 44307.07            8873.1
                                          AS HEXANE    7384.523
        MAGA INDEX        0.625
        GM INDEX          3.013
        AVE. C NUMBER     4.993
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      AROMATICS

MC     PCT   CARBON NO    PPM      PCT   REAC. NO.  REACT    PCT

26    2.18      6.00    160.71    1.81      0.56    90.00    0.34
61    5.21      7.00    330.09    3.72      2.20   726.19    2.72
88    1.17      8.00     64.86    0.73      2.03   131.67    0.49
11    4.59      8.00    254.14    2.86      4.92  1250.36    4.68
0     0.0       8.00      0.0     0.0       3.50     0.0     0.0

72    2.13      8.00    117.72    1.33      3.64   428.48    1.60
19    0.01      9.00      0.35    0.00      1.64     0.58    0.00
35    0.42      9.00     20.48    0.23      1.70    34.82    0.13
23    1.59      9.00     78.14    0.88      4.10   320.36    1.20
08    0.66      9.00     32.69    0.37      8.64   282.31    1.06

0     0.0      10.00      0.0     0.0       6.00     0.0     0.0
09    0.75      9.00     37.01    0.42      3.40   125.83    0.47
20    0.13     10.00      5.62    0.06      6.00    33.72    0.13
47    1.80      9.33     85.69    0.97      3.20   274.20    1.03
32    0.06     10.00      2.53    0.03      1.00     2.53    0.01

70    0.06      9.50      2.60    0.03      5.00    13.00    0.05
20    0.25      9.50     11.81    0.13      5.80    68.50    0.26
61    0.14      9.50      6.70    0.08      3.00    20.09    0.08
06    0.05     10.00      2.31    0.03      2.90     6.69    0.03
90    0.28     10.00     12.29    0.14      4.20    51.62    0.19

77    0.15     10.00      6.58    0.07      3.40    22.36    0.08
0     0.0      11.00      0.0     0.0       5.00     0.0     0.0

73 21.62               1232.29   13.89            3883.32   14.52
                7.77                        3.15

      ACETYLENES

MC     PCT   CARBON NO    PPM      PCT   REAC. NO.  REACT    PCT

43    2.42      2.00    536.22    6.04      0.0      0.0     0.0
91    0.04      3.00      5.97    0.07      3.90    23.28    0.09
0     0.0       4.00      0.0     0.0      18.98     0.0     0.0

34    2.46              542.18    6.11             23.28    0.09
                2.01                        0.04


MC                       PPM                    REACTIVITY
*** 44307.07          8873.133                 *********
523                                             26737.24
                                                26737.24
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J

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                                                                                  PARAFFINS
   PEAK                    NAME                                       PPMC     PCT     CARBON NO

     1  METHANE                                                     607.94    1.22       1.00
     2  ETHANE                                                      124.81    0.25       2.00
     6  PROPANE                                                      17.46    0.03       3.00
     8  IB                                                          169.08    0.34       4.00
    10  NB 22DMPR                                                  1457.95    2.92       4.50

    16  IP                                                         2676.42    5.36       5.00
    19  NP                                                         1305.88    2.62       5.00
    25  22DMB                                                        62.74    0.13       6.00
    28  CP                                                          129.43    0.26       5.00
    29  23DMB                                                       604.11    1.21       6.00

    30  2MP                                                        1260.15    2.52       6.00
    31  3MP                                                         786.03    1.57       6.00
    33  NHX                                                         957.14    1.92       6.00
    37  MCP 22DMP                                                   629.79    1.26       6.50
    38  24DMP 223TMB                                                545.99    1.09       7.00

    40  33DMP CHX                                                   249.39    0.50       6.50
    42  23DMP 2MHX                                                 1314.10    2.63       7.00
    43  3MHX UNK 4                                                  741.65    1.49       7.00
   431  UNK 4A                                                         0.0     0.0       7.00
   432  UNK 4B                                                      143.06    0.29       7.00

   433  UNK 4C                                                         0.0     0.0       7.00
    44  3EP 224TMP                                                 2181.46    4.37       8.00
    45  NHP                                                         549.93    1.10       7.00
    47  MCHX 22DMHX                                                 315.18    0.63       7.50
   471  UNK 4D                                                       34.13    0.07       8.00

    48  UNK 5                                                        50.01    0.10       8.00
    49  223TMP 25DMHX 24DMHX                                        729.03    1.46       8.00
   491  UNK 5B                                                         0.0     0.0       8.00
   492  UNK 5C                                                         0.0     0.0       8.00
    50  33DMHX 234TMP 233TMP 23DMHX                                1710.05    3.43       8.00

    51  UNK 6                                                       211.09    0.42       8.00
    52  UNK 7                                                       374.88    0.75       8.00
    53  3MHP                                                        248.15    0.50       8.00
    54  225TMHX T12DMCHX                                            357.19    0.72       8.00
   541  UNK 9A                                                       11.26    0.02       8.00

   542  UNK 9B                                                       10.59    0.02       8.00
    55  NOC                                                         197.92    0.40       8.00
    56  UNK 10                                                         0.0     0.0       9.00
    57  UNK 11                                                       29.63    0.06       9.00
    59  C12DMCHX                                                     17.35    0.03       8.00

    60  UNK 12                                                       17.46    0.03       9.00
    61  UNK 13                                                       38.97    0.08       9.00
    62  UNK 15                                                       33.91    0.07       9.00
    63  UNK 17                                                        6.53    0.01       9.00
    64  UNK 18                                                       29.63    0.06       9.00

    65  UNK 19                                                       79.86    0.16       9.00
   651  UNK 19A                                                      61.62    0.12       9.00
   652  UNK 19B                                                        0.0     0.0       9.00
    66  UNK 20                                                         0.0     0.0       9.00
    67  UNK 21                                                       36.38    0.07       9.00

    68  UNK 22                                                        2.70    0.01       9.00
    69  NN                                                           99.80    0.20       9.00
    70  UNK 25                                                       12.62    0.03      10.00
    71  UNK 26                                                        2.25    0.00      10.00
    72  UNK 28                                                        2.25    0.00      10.00

    73  UNK 30                                                        3.72    0.01      10.00
    74  UNK 31                                                        2.70    0.01      10.00
    75  UNK 32                                                        0.23    0.00      10.00
    76  UNK 33                                                       34.36    0.07      10.00
    77  UNK 34                                                        4.39    0.01      10.00

    78  UNK 35                                                         0.0     0.0      10.00
    79  ND                                                           88.88    0.18      10.00
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B

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.94   1.22     1.00    607.94   7.04     0.0     0.0    0.0
.81   0.25     2.00     62.40   0.72     0.42   26.21   0.08
.46   0.03     3.00      5.82   0.07     0.66    3.84   0.01
.08   0.34     4.00     42.27   0.49     1.05   44.38   0.14
.95   2.92     4.50    323.99   3.75     1.27  411.47   1.30

.42   5.36     5.00    535.28   6.20     1.66  888.57   2.81
.88   2.62     5.00    261.18   3.02     1.58  412.66   1.31
.74   0.13     6.00     10.46   0.12     1.34   14.01   0.04
.43   0.26     5.00     25.89   0.30     1.56   40.38   0.13
.11   1.21     6.00    100.68   1.17     1.86  187.27   0.59

.15   2.52     6.00    210.02   2.43     1.59  333.94   1.06
.03   1.57     6.00    131.00   1.52     1.64  214.85   0.68
.14   1.92     6.00    159.52   1.85     1.58  252.05   0.80
.79   1.26     6.50     96.89   1.12    -1.90  184.09   0.58
.99   1.09     7.00     78.00   0.90     1.30  101.40   0.32

.39   0.50     6.50     38.37   0.44     1.50   57.55   0.18
.10   2.63     7.00    187.73   2.17     1.50  281.59   0.89
.65   1.49     7.00    105.95   1.23     1.50  158.92   0.50
.0    0.0      7.00      0.0    0.0      1.50    0.0    0.0
.06   0.29     7.00     20.44   0.24     1.50   30.66   0.10

.0    0.0      7.00      0.0    0.0      1.50    0.0    0.0
.46   4.37     8.00    272.68   3.16     1.30  354.49   1.12
.93   1.10     7.00     78.56   0.91     1.51  118.63   0.38
.18   0.63     7.50     42.02   0.47     1.60   67.24   0.21
.13   0.07     8.00      4.27   0.05     1.50    6.40   0.02

.01   0.10     8.00      6.25   0.07     1.50    9.38   0.03
.03   1.46     8.00     91.13   1.06     1.50  136.69   0.43
.0    0.0      8.00      0.0    0.0      1.50    0.0    0.0
.0    0.0      8.00      0.0    0.0      1.50    0.0    0.0
.05   3.43     8.00    213.76   2.47     1.60  342.01   1.08

.09   0.42     8.00     26.39   0.31     1.50   39.58   0.13
.88   0.75     8.00     46.86   0.54     1.50   70.29   0.22
.15   0.50     8.00     31.02   0.36     1.63   50.56   0.16
.19   0.72     8.00     44.65   0.52     1.60   71.44   0.23
.26   0.02     8.00      1.41   0.02     1.50    2.11   0.01

.59   0.02     8.00      1.32   0.02     1.50    1.99   0.01
.92   0.40     8.00     24.74   0.29     1.46   36.12   0.11
.0    0.0      9.00      0.0    0.0      1.50    0.0    0.0
.63   0.06     9.00      3.29   0.04     1.50    4.94   0.02
.35   0.03     8.00      2.17   0.03     1.70    3.69   0.01

.46   0.03     9.00      1.94   0.02     1.50    2.91   0.01
.97   0.08     9.00      4.33   0.05     1.50    6.50   0.02
.91   0.07     9.00      3.77   0.04     1.50    5.65   0.02
.53   0.01     9.00      0.73   0.01     1.50    1.09   0.00
.63   0.06     9.00      3.29   0.04     1.50    4.94   0.02

.86   0.16     9.00      8.87   0.10     1.50   13.31   0.04
.62   0.12     9.00      6.85   0.08     1.50   10.27   0.03
.0    0.0      9.00      0.0    0.0      1.50    0.0    0.0
.0    0.0      9.00      0.0    0.0      1.50    0.0    0.0
.38   0.07     9.00      4.04   0.05     1.50    6.06   0.02

.70   0.01     9.00      0.30   0.00     1.50    0.45   0.00
.80   0.20     9.00     11.09   0.13     1.42   15.75   0.05
.62   0.03    10.00      1.26   0.01     1.50    1.89   0.01
.25   0.00    10.00      0.23   0.00     1.50    0.34   0.00
.25   0.00    10.00      0.23   0.00     1.50    0.34   0.00

.72   0.01    10.00      0.37   0.00     1.50    0.56   0.00
.70   0.01    10.00      0.27   0.00     1.50    0.41   0.00
.23   0.00    10.00      0.02   0.00     1.50    0.03   0.00
.36   0.07    10.00      3.44   0.04     1.50    5.15   0.02
.39   0.01    10.00      0.44   0.01     1.50    0.66   0.00

.0    0.0     10.00      0.0    0.0      1.50    0.0    0.0
.88   0.18    10.00      8.89   0.10     1.60   12.44   0.04
.0    0.0     11.00      0.0    0.0      1.50    0.0    0.0
.0    0.0     11.00      0.0    0.0      1.50    0.0    0.0
.0    0.0     11.00      0.0    0.0      1.50    0.0    0.0
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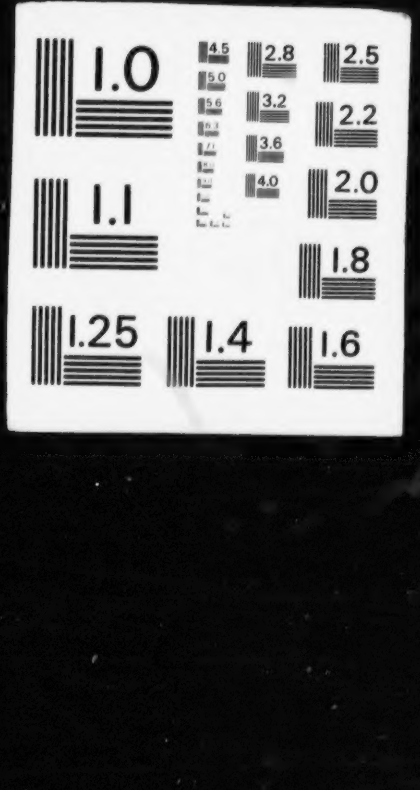
2 OF 2

PB

194145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2.2
2.0
1.1
1.8
1.25
1.4
1.6

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 542  UNK 9B                                   10.59  0.02      8.00
  55  NOC                                     197.92  0.40      8.00
  56  UNK 10                                    0.0   0.0       9.00
  57  UNK 11                                   29.63  0.06      9.00
  59  C12DMCHX                                 17.35  0.03      8.00

  60  UNK 12                                   17.46  0.03      9.00
  61  UNK 13                                   38.97  0.08      9.00
  62  UNK 15                                   33.91  0.07      9.00
  63  UNK 17                                    6.53  0.01      9.00
  64  UNK 18                                   29.63  0.06      9.00

  65  UNK 19                                   79.86  0.16      9.00
 651  UNK 19A                                  61.62  0.12      9.00
 652  UNK 19B                                   0.0   0.0       9.00
  66  UNK 20                                    0.0   0.0       9.00
  67  UNK 21                                   36.38  0.07      9.00

  68  UNK 22                                    2.70  0.01      9.00
  69  NN                                       99.80  0.20      9.00
  70  UNK 25                                   12.62  0.03     10.00
  71  UNK 26                                    2.25  0.00     10.00
  72  UNK 28                                    2.25  0.00     10.00

  73  UNK 30                                    3.72  0.01     10.00
  74  UNK 31                                    2.70  0.01     10.00
  75  UNK 32                                    0.23  0.00     10.00
  76  UNK 33                                   34.36  0.07     10.00
  77  UNK 34                                    4.39  0.01     10.00

  78  UNK 35                                    0.0   0.0      10.00
  79  ND                                       88.88  0.18     10.00
  80  UNK 37                                    0.0   0.0      11.00
  81  UNK 38                                    0.0   0.0      11.00
  82  UNK 39                                    0.0   0.0      11.00

  83  UNK 40                                    0.0   0.0      11.00
  84  UNK 41                                    0.0   0.0      11.00
  85  OTHER PARAFFINS                          45.06  0.09     11.50

            TOTAL                           21414.20 42.90
            AVERAGE                                             5.41
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TEST OLSON LAB SAMPLE NO 2 YAMAHA 305

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0    213.76    2.47       1.60    342.01    [illegible]

0     26.39    0.31       1.50     39.58    0.13
0     46.86    0.54       1.50     70.29    0.22
0     31.02    0.36       1.63     50.56    0.16
0     44.65    0.52       1.60     71.44    0.23
0      1.41    0.02       1.50      2.11    0.01

0      1.32    0.02       1.50      1.99    0.01
0     24.74    0.29       1.46     36.12    0.11
0      0.0     0.0        1.50      0.0     0.0
0      3.29    0.04       1.50      4.94    0.02
0      2.17    0.03       1.70      3.69    0.01

0      1.94    0.02       1.50      2.91    0.01
0      4.33    0.05       1.50      6.50    0.02
0      3.77    0.04       1.50      5.65    0.02
0      0.73    0.01       1.50      1.09    0.00
0      3.29    0.04       1.50      4.94    0.02

0      8.87    0.10       1.50     13.31    0.04
0      6.85    0.08       1.50     10.27    0.03
0      0.0     0.0        1.50      0.0     0.0
00     0.0     0.0        1.50      0.0     0.0
00     4.04    0.05       1.50      6.06    0.02

00     0.30    0.00       1.50      0.45    0.00
00    11.09    0.13       1.42     15.75    0.05
00     1.26    0.01       1.50      1.89    0.01
00     0.23    0.00       1.50      0.34    0.00
00     0.23    0.00       1.50      0.34    0.00

00     0.37    0.00       1.50      0.56    0.00
00     0.27    0.00       1.50      0.41    0.00
00     0.02    0.00       1.50      0.03    0.00
00     3.44    0.04       1.50      5.15    0.02
00     0.44    0.01       1.50      0.66    0.00

00     0.0     0.0        1.50      0.0     0.0
00     8.89    0.10       1.40     12.44    0.04
00     0.0     0.0        1.50      0.0     0.0
00     0.0     0.0        1.50      0.0     0.0
00     0.0     0.0        1.50      0.0     0.0

00     0.0     0.0        1.50      0.0     0.0
00     0.0     0.0        1.50      0.0     0.0
50     3.92    0.05       1.50      5.88    0.02

    3958.61   45.83              5053.94   15.99
41                        1.28
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P

6274

F

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TEST OLSON LAB SAMPLE NO 2  YAMAHA 305

PEAK                      NAME                          PPMC    P

   3  ETHYLENE                                       1092.16   2.
   5  PROPYLENE                                       634.52   1.
   7  PROPADIENE                                       25.02   0.
   9  1B IBE 13B                                      579.69   1.
  11  T2B                                             172.85   0.

  12  UNK 1                                            17.18   0.
  13  C2B                                             140.63   0.
  14  UNK 1A2                                           1.90   0.
  15  3M1B                                             69.62   0.
  17  1P                                              173.73   0.

  18  2M1B                                            308.04   0.
  20  2M13B                                            94.89   0.
  21  T2P                                             336.47   0.6
  22  C2P                                             176.26   0.
  23  2M2B                                            614.31   1.

  24  T13P                                             58.25   0.
  25  UNK 2                                             6.93   0.
  26  C13P                                              0.0    0.
  27  CPE                                              84.91   0.
  28  4M1P                                             66.82   0.

  29  23DM1B                                           61.50   0.
 291  UNK 2A2                                           0.0    0.
  30  4MT2P                                           119.11   0.2
 301  4MC2P                                             0.0    0.
  31  UNK 3                                            39.27   0.0

  32  2M1P 1HX                                        223.64   0.4
  33  2E1B                                             17.47   0.0
  34  C3HX T3HX T2HX                                  299.95   0.6
  35  2M2P 3MT2P                                      304.75   0.6
  36  23DM13B C2HX                                     77.45   0.1

  37  3MC2P                                           177.56   0.3
 371  UNK 3A2                                           0.0    0.0
  38  23DM2B 233TM1B                                   71.42   0.1
 381  UNK 3B2                                          18.07   0.0
  39  1MCPE 34DM1P                                      0.0    0.0

  41  5M1HX                                            59.76   0.1
 411  UNK 3C2                                          28.81   0.0
  42  CHXE                                            162.35   0.3
  43  5MT2HX 34DMC2P 5MC2HX 34DMT2P                    63.32   0.1
 431  UNK 4A2                                           0.0    0.0

 432  UNK 4B2                                           0.0    0.0
 433  UNK 4C2                                         134.31   0.2
  44  2M1HX 1HP                                         0.0    0.0
 441  UNK 4D2                                         110.56   0.2
  45  2M2HX T3HP C3HP                                 187.06   0.3

 451  UNK 4E2                                           0.0    0.0
  46  244TM1P 3E2P T2HP                               119.65   0.2
 461  UNK 4F2                                          40.18   0.0
  47  23DM2P C2HP                                      99.08   0.2
 471  UNK 4G2                                           0.0    0.0

  48  UNK 5A2                                          27.55   0.0
  49  244TM2P 4MCHXE 3MCHXE                           110.35   0.22
 491  UNK 5B2                                           0.0    0.0
 492  UNK 5C2                                           0.0    0.0
  51  1MCHXE                                          258.87   0.5
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        OLEFINS

MC      PCT     CARBON NO      PPM        PCT     REAC. NO.  REACT     PCT

16     2.19       2.00       546.08      6.32       2.88  1572.71    6.97
52     1.27       3.00       211.51      2.45       5.93  1254.24    3.97
02     0.05       3.00         8.34      0.10       3.90    32.52    0.10
69     1.16       4.00       144.92      1.68       6.04   875.33    2.77
85     0.35       4.00        43.21      0.50      18.98   820.15    2.59

18     0.03       4.00         4.30      0.05      15.00    64.44    0.20
63     0.28       4.00        35.16      0.41      12.03   422.93    1.34
90     0.00       4.00         0.47      0.01       4.00     1.90    0.01
62     0.14       5.00        13.92      0.16       4.58    63.77    0.20
73     0.35       5.00        34.75      0.40       3.56   123.70    0.39

04     0.62       5.00        61.61      0.71       5.76   354.86    1.12
89     0.19       5.00        18.98      0.22       6.27   118.99    0.38
47     0.67       5.00        67.29      0.78      13.05   878.18    2.78
26     0.35       5.00        35.25      0.41       9.15   322.55    1.02
31     1.23       5.00       122.85      1.42      32.20  3956.15   12.51

25     0.12       5.00        11.65      0.13       6.80    79.22    0.25
93     0.01       5.00         1.39      0.02       4.00     5.54    0.02
0      0.0        5.00         0.0       0.0        6.80     0.0     0.0
91     0.17       5.00        16.98      0.20      38.98   661.93    2.09
82     0.13       6.00        11.14      0.13       3.90    43.43    0.14

50     0.12       6.00        10.25      0.12       3.73    38.23    0.12
0      0.0        6.00         0.0       0.0        4.00     0.0     0.0
11     0.24       6.00        19.85      0.23       6.61   131.22    0.42
0      0.0        6.00         0.0       0.0        6.50     0.0     0.0
27     0.08       6.00         6.55      0.08       4.00    26.18    0.08

64     0.45       6.00        37.27      0.43       3.39   126.36    0.40
47     0.03       6.00         2.91      0.03       3.90    11.35    0.04
95     0.60       6.00        49.99      0.58       8.40   419.93    1.33
75     0.61       6.00        50.79      0.59      27.12  1377.49    4.36
45     0.16       6.00        12.91      0.15      20.30   262.05    0.83

56     0.36       6.00        29.59      0.34      17.00   503.09    1.59
0      0.0        6.00         0.0       0.0       25.00     0.0     0.0
42     0.14       6.50        10.99      0.13      52.90   581.21    1.84
07     0.04       7.00         2.58      0.03      25.00    64.53    0.20
0      0.0        6.50         0.0       0.0       25.00     0.0     0.0

76     0.12       7.00         8.54      0.10       2.50    21.34    0.07
81     0.06       7.00         4.12      0.05       2.50    10.29    0.03
35     0.33       6.00        27.06      0.31       5.93   160.46    0.51
32     0.13       7.00         9.05      0.10      11.00    99.50    0.31
0      0.0        7.00         0.0       0.0       10.00     0.0     0.0

0      0.0        7.00         0.0       0.0       10.00     0.0     0.0
31     0.27       7.00        19.19      0.22      10.00   191.87    0.61
0      0.0        7.00         0.0       0.0        2.80     0.0     0.0
56     0.22       7.00        15.79      0.18       7.00   110.56    0.35
06     0.37       7.00        26.72      0.31      11.30   301.96    0.96

0      0.0        7.00         0.0       0.0       10.00     0.0     0.0
.65    0.24       7.33        16.32      0.19       9.40   153.44    0.49
.18    0.08       7.00         5.74      0.07      10.00    57.40    0.18
.08    0.20       7.00        14.15      0.16      47.00   665.25    2.10
.0     0.0        7.00         0.0       0.0       30.00     0.0     0.0

.55    0.06       7.00         3.94      0.05      30.00   118.07    0.37
.35    0.22       7.33        15.05      0.17      13.00   195.71    0.62
.0     0.0        7.33         0.0       0.0       13.00     0.0     0.0
.0     0.0        7.33         0.0       0.0       13.00     0.0     0.0
.87    0.52       7.00        36.98      0.43       9.73   359.83    1.14

.30    0.25       8.00        15.54      0.18       7.00   108.77    0.34
.47    0.39       8.00        24.43      0.28       7.00   171.04    0.54
.70    0.30       8.00        18.84      0.22       2.80    52.75    0.17
.65    0.15       8.00         9.58      0.11       2.50    23.95    0.08
.11    0.15       8.00         9.14      0.11       2.50    22.85    0.07
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 39  1MCPE 34DM1P                                   0.0     0.0

 41  5M1HX                                         59.76   0.12       7.00
411  UNK 3C2                                       28.81   0.06       7.00
 42  CHXE                                         162.35   0.33       6.00
 43  5MT2HX 34DMC2P 5MC2HX 34DMT2P                 63.32   0.13       7.00
431  UNK 4A2                                        0.0    0.0        7.00

432  UNK 4B2                                        0.0    0.0        7.00
433  UNK 4C2                                      134.31   0.27       7.00
 44  2M1HX 1MP                                      0.0    0.0        7.00
441  UNK 4D2                                      110.56   0.22       7.00
 45  2M2HX T3HP C3HP                              187.06   0.37       7.00

451  UNK 4E2                                        0.0    0.0        7.00
 46  244TM1P 3E2P T2HP                            119.65   0.24       7.33
461  UNK 4F2                                       40.18   0.08       7.00
 47  23DM2P C2HP                                   99.08   0.20       7.00
471  UNK 4G2                                        0.0    0.0        7.00

 48  UNK 5A2                                       27.55   0.06       7.00
 49  244TM2P 4MCHXE 3MCHXE                        110.35   0.22       7.33
491  UNK 5B2                                        0.0    0.0        7.33
492  UNK 5C2                                        0.0    0.0        7.33
 51  1MCHXE                                       258.87   0.52       7.00

 52  UNK 8                                        124.30   0.25       8.00
 53  UNK 9                                        195.47   0.39       8.00
 54  10C 2E1HX                                    150.70   0.30       8.00
541  UNK 9A2                                       76.65   0.15       8.00
542  UNK 9B2                                       73.11   0.15       8.00

 55  23DM2HX T40C 2M2HP                            58.63   0.12       8.00
 56  UNK 9C2                                       64.94   0.13       8.00
 57  26DM3HP                                       61.76   0.12       9.00
 58  T20C C20C                                      0.0    0.0        8.00
 60  4EECHXE                                       14.03   0.03       8.00

601  UNK 13A2                                       0.0    0.0        8.00
 61  UNK 14                                        22.92   0.05       9.00
611  UNK 14A2                                       0.0    0.0        9.00
 62  UNK 16                                        69.12   0.14       9.00
621  UNK 16A2                                       0.0    0.0        9.00

631  UNK 17A2                                       0.0    0.0        9.00
 65  12DMCHXE                                     160.70   0.32       8.00
651  UNK 19A2                                       0.0    0.0        9.00
 67  UNK 21A2                                     107.04   0.21       9.00
 68  UNK 23                                       111.59   0.22       9.00

 69  UNK 24                                       140.38   0.28       9.00
691  UNK 24A2                                       0.0    0.0       10.00
 71  UNK 27                                        35.77   0.07      10.00
711  UNK 27A2                                       0.0    0.0       10.00
 72  UNK 29                                        43.99   0.09      10.00

721  UNK 29A2                                      13.77   0.03      10.00
741  UNK 31A2                                       0.0    0.0       10.00
 85  OTHER OLEFINS                                  0.0    0.0       11.00

          TOTAL                                  8990.99 18.01
          AVERAGE                                                     4.48


TEST  OLSON LAB SAMPLE NO 2  YAMAHA 305
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.0	6.00	0.0	0.0	25.00	0.0	0.0
.14	6.50	10.99	0.13	52.90	581.21	1.84
.04	7.00	2.58	0.03	25.00	64.53	0.20
.0	6.50	0.0	0.0	25.00	0.0	0.0
.12	7.00	8.54	0.10	2.50	21.34	0.07
.06	7.00	4.12	0.05	2.50	10.29	0.03
.33	6.00	27.06	0.31	5.93	160.46	0.51
.13	7.00	9.05	0.10	11.00	99.50	0.31
.0	7.00	0.0	0.0	10.00	0.0	0.0
.0	7.00	0.0	0.0	10.00	0.0	0.0
.27	7.00	19.19	0.22	10.00	191.87	0.61
.0	7.00	0.0	0.0	2.80	0.0	0.0
.22	7.00	15.79	0.18	7.00	110.56	0.35
.37	7.00	26.72	0.31	11.30	301.96	0.96
.0	7.00	0.0	0.0	10.00	0.0	0.0
0.24	7.33	16.32	0.19	9.40	153.44	0.49
0.08	7.00	5.74	0.07	10.00	57.40	0.18
0.20	7.00	14.15	0.16	47.00	665.25	2.10
0.0	7.00	0.0	0.0	30.00	0.0	0.0
0.06	7.00	3.94	0.05	30.00	118.07	0.37
0.22	7.33	15.05	0.17	13.00	195.71	0.62
0.0	7.33	0.0	0.0	13.00	0.0	0.0
0.0	7.33	0.0	0.0	13.00	0.0	0.0
0.52	7.00	36.98	0.43	9.73	359.83	1.14
0.25	8.00	15.54	0.18	7.00	108.77	0.34
0.39	8.00	24.43	0.28	7.00	171.04	0.54
0.30	8.00	18.84	0.22	2.80	52.75	0.17
0.15	8.00	9.58	0.11	2.50	23.95	0.08
0.15	8.00	9.14	0.11	2.50	22.85	0.07
0.12	8.00	7.33	0.08	27.85	204.11	0.65
0.13	8.00	8.12	0.09	7.00	56.83	0.18
0.12	9.00	6.86	0.08	6.80	46.66	0.15
0.0	8.00	0.0	0.0	4.80	0.0	0.0
0.03	8.00	1.75	0.02	3.05	5.35	0.02
0.0	8.00	0.0	0.0	6.00	0.0	0.0
0.05	9.00	2.55	0.03	6.00	15.28	0.05
0.0	9.00	0.0	0.0	6.00	0.0	0.0
0.14	9.00	7.68	0.09	6.00	46.08	0.15
0.0	9.00	0.0	0.0	6.00	0.0	0.0
0.0	9.00	0.0	0.0	6.00	0.0	0.0
0.32	8.00	20.09	0.23	15.42	309.75	0.98
0.0	9.00	0.0	0.0	6.00	0.0	0.0
0.21	9.00	11.89	0.14	6.00	71.36	0.23
0.22	9.00	12.40	0.14	6.00	74.39	0.24
0.28	9.00	15.60	0.18	6.00	93.59	0.30
0.0	10.00	0.0	0.0	6.00	0.0	0.0
0.07	10.00	3.58	0.04	6.00	21.46	0.07
0.0	10.00	0.0	0.0	6.00	0.0	0.0
0.09	10.00	4.40	0.05	6.00	26.39	0.08
0.03	10.00	1.39	0.02	6.00	8.26	0.03
0.0	10.00	0.0	0.0	6.00	0.0	0.0
0.0	11.00	0.0	0.0	6.00	0.0	0.0
18.01		2007.28	23.24		*******	60.09
	4.48			9.46	18998.6	

#

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 TEST OLSON LAB SAMPLE NO 2  YAMAHA 305                              AROMATIC

PEAK                         NAME                               PPMC    PCT    CA


  39  BZ                                                     1012.61  2.03
  50  TOL                                                    5212.02 10.44
  63  EBZ                                                     758.78  1.52
  64  PX MX                                                  2384.00  4.78
 652  PHEE (STYRENE)                                            0.0   0.0

  66  OX                                                     1161.80  2.33
  70  IPRBZ                                                    45.85  0.09
  73  NPRBZ                                                   307.87  0.62
  74  1M3EBZ 1M4EBZ                                          1303.95  2.61
  75  135TMBZ                                                 565.99  1.13

 751  UNK 32A3                                                  0.0   0.0
  76  1M2EBZ 2PH1PR                                           668.96  1.34
 761  UNK 33A3                                                 73.72  0.15
  77  C1PH1PR TBBZ 124TMBZ                                   1945.18  3.90
  78  IBBZ SBBZ                                               139.24  0.28

  79  UNK 36                                                   70.54  0.14
  80  1M3IPRBZ 123TMBZ                                        426.17  0.85
  81  1M4IPRBZ T1PH1PR                                        202.68  0.41
  82  1M2IPRBZ                                                138.90  0.28
  83  13DEBZ 1M3NPRBZ                                         401.79  0.81

  84  1M4NPRBZ NBBZ 12DEBZ 13DM5EBZ 14DEBZ                    189.40  0.38
  85  OTHER AROMATICS                                        1767.85  3.54

           TOTAL                                            18777.27 37.62
           AVERAGE
 TEST OLSON LAB SAMPLE NO 2  YAMAHA 305                              ACETYLE

PEAK                         NAME                               PPMC    PCT    C


   4  ACETYLENE                                               709.98  1.42
 107  MA                                                       18.60  0.04
  13  EA WITH C2B                                               0.0   0.0

           TOTAL                                              728.57  1.46
           AVERAGE


           GRAND TOTALS                                         PPMC
                                                           ********* 49910.8
                                            AS HEXANE      8318.500

           MAGA INDEX       0.723
           GM INDEX         3.661
           AVE. C NUMBER    5.779
```

I

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ATICS

 CARBON NO     PPM      PCT    REAC. NO.  REACT    PCT


    6.00     168.77    1.95      0.56    94.51    0.30
    7.00     744.57    8.62      2.20  1638.06    5.18
    8.00      94.85    1.10      2.03   192.54    0.61
    8.00     298.00    3.45      4.92  1466.16    4.64
    8.00       0.0     0.0       3.50     0.0     0.0

    8.00     145.22    1.68      3.64   528.62    1.67
    9.00       5.09    0.06      1.64     8.35    0.03
    9.00      34.21    0.40      1.70    58.15    0.18
    9.00     144.88    1.68      4.10   594.02    1.88
    9.00      62.89    0.73      8.64   543.35    1.72

   10.00       0.0     0.0       6.00     0.0     0.0
    9.00      74.33    0.86      3.40   252.72    0.80
   10.00       7.37    0.09      6.00    44.23    0.14
    9.33     208.49    2.41      3.20   667.16    2.11
   10.00      13.92    0.16      1.00    13.92    0.04

    9.50       7.42    0.09      5.00    37.12    0.12
    9.50      44.86    0.52      5.80   260.19    0.82
    9.50      21.34    0.25      3.00    64.01    0.20
   10.00      13.89    0.16      2.90    40.28    0.13
   10.00      40.18    0.47      4.20   168.75    0.53

   10.00      18.94    0.22      3.40    64.39    0.20
   11.00     160.71    1.86      5.00   803.57    2.54

            2309.94   26.74            7540.09   23.85
    8.13                         3.26

YLENES

 CARBON NO     PPM      PCT    REAC. NO.  REACT    PCT


    2.00     354.99    4.11      0.0      0.0     0.0
    3.00       6.20    0.07      3.90    24.18    0.08
    4.00       0.0     0.0      18.98     0.0     0.0

             361.19    4.18              24.18    0.08
    2.02                         0.07


               PPM                    REACTIVITY
.52         8636.875                  ********
                                      31616.88
```

TEST OLSON LAB SAMPLE NO 3 SUZUKI 250

PARAFFINS

A

PEAK	NAME	PPMC	PCT	CAR
1	METHANE	587.24	1.26	1
2	ETHANE	40.33	0.09	2
6	PROPANE	13.53	0.03	3
8	IB	301.95	0.65	4
10	NB 22DMPR	2215.80	4.74	4
16	IP	2825.92	6.05	5
19	NP	1061.48	2.27	5
25	22DMB	94.47	0.20	6
28	CP	86.08	0.19	5
29	23DMB	906.51	1.94	6
30	2MP	1085.16	2.32	6
31	3MP	689.16	1.48	6
33	NHX	716.09	1.53	6
37	MCP 22DMP	368.40	0.79	6
38	24DMP 223TMB	854.27	1.83	7
40	33DMP CHX	140.08	0.30	6
42	23DMP 2MHX	1641.14	3.51	7
43	3MHX UNK 4	641.38	1.37	7
431	UNK 4A	0.0	0.0	7
432	UNK 4B	70.78	0.15	7
433	UNK 4C	0.0	0.0	7
44	3EP 224TMP	3755.30	8.04	8
45	NHP	487.09	1.04	7
47	MCHX 22DMHX	155.78	0.33	7
471	UNK 4D	13.40	0.03	8
48	UNK 5	18.81	0.04	8
49	223TMP 25DMHX 24DMHX	1240.67	2.66	8
491	UNK 5B	0.0	0.0	8
492	UNK 5C	0.0	0.0	8
50	33DMHX 234TMP 233TMP 23DMHX	3362.68	7.20	8
51	UNK 6	415.50	0.89	8
52	UNK 7	327.25	0.70	8
53	3MHP	203.42	0.44	8
54	225TMHX T12DMCHX	687.80	1.47	8
541	UNK 9A	0.0	0.0	9
542	UNK 9B	2.98	0.01	6
55	NOC	151.72	0.32	8
56	UNK 10	0.0	0.0	9
57	UNK 11	92.57	0.20	9
59	C12DMCHX	12.99	0.03	8
60	UNK 12	12.99	0.03	9
61	UNK 13	20.98	0.04	9
62	UNK 15	44.12	0.09	9
63	UNK 17	10.83	0.02	9
64	UNK 18	26.80	0.06	9
65	UNK 19	54.81	0.12	9
651	UNK 19A	60.63	0.13	9
652	UNK 19B	0.0	0.0	9
66	UNK 20	0.0	0.0	9
67	UNK 21	59.41	0.13	9
68	UNK 22	20.98	0.04	9
69	NN	64.56	0.14	9
70	UNK 25	4.06	0.01	10
71	UNK 26	1.62	0.00	10
72	UNK 28	2.71	0.01	10
73	UNK 30	1.22	0.00	10

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     PARAFFINS

MC    PCT   CARBON NO    PPM      PCT    REAC. NO.  REACT    PCT

24   1.26      1.00     587.24   7.42      0.0      0.0     0.0
33   0.09      2.00      20.17   0.25      0.42     8.47    0.04
53   0.03      3.00       4.51   0.06      0.66     2.98    0.01
95   0.65      4.00      75.49   0.95      1.05    79.26    0.38
80   4.74      4.50     492.40   6.22      1.27   625.35    2.98

92   6.05      5.00     565.18   7.14      1.66   938.20    4.47
48   2.27      5.00     212.30   2.68      1.58   335.43    1.60
47   0.20      6.00      15.74   0.20      1.34    21.10    0.10
08   0.19      5.00      17.22   0.22      1.55    26.86    0.13
51   1.94      6.00     151.09   1.91      1.86   281.02    1.34

16   2.32      6.00     180.86   2.28      1.59   287.57    1.37
16   1.48      6.00     114.86   1.45      1.64   188.37    0.90
09   1.53      6.00     119.35   1.51      1.58   188.57    0.90
40   0.79      6.50      56.68   0.72      1.90   107.69    0.51
27   1.83      7.00     122.04   1.54      1.30   158.65    0.76

08   0.30      6.50      21.55   0.27      1.50    32.33    0.15
14   3.51      7.00     234.45   2.96      1.50   351.67    1.68
38   1.37      7.00      91.63   1.16      1.50   137.44    0.66
.0   0.0       7.00       0.0    0.0       1.50     0.0     0.0
.78  0.15      7.00      10.11   0.13      1.50    15.17    0.07

.0   0.0       7.00       0.0    0.0       1.50     0.0     0.0
.30  8.04      6.00     469.41   5.93      1.30   610.24    2.91
.09  1.04      7.00      69.58   0.88      1.51   105.07    0.50
78   0.33      7.50      20.77   0.26      1.60    33.23    0.16
40   0.03      8.00       1.67   0.02      1.50     2.51    0.01

.81  0.04      8.00       2.35   0.03      1.50     3.53    0.02
.67  2.66      8.00     155.08   1.96      1.50   232.63    1.11
.0   0.0       8.00       0.0    0.0       1.50     0.0     0.0
.0   0.0       8.00       0.0    0.0       1.50     0.0     0.0
.68  7.20      8.00     420.33   5.31      1.60   672.54    3.21

.50  0.89      8.00      51.94   0.66      1.50    77.91    0.37
.25  0.70      8.00      40.91   0.52      1.50    61.36    0.29
.42  0.44      8.00      25.43   0.32      1.63    41.45    0.20
.80  1.47      8.00      85.98   1.09      1.60   137.56    0.66
.0   0.0       8.00       0.0    0.0       1.50     0.0     0.0

.98  0.01      8.00       0.37   0.00      1.50     0.56    0.00
.72  0.32      8.00      18.96   0.24      1.46    27.69    0.13
.0   0.0       9.00       0.0    0.0       1.50     0.0     0.0
.57  0.20      9.00      10.29   0.13      1.50    15.43    0.07
.99  0.03      8.00       1.62   0.02      1.70     2.76    0.01

.99  0.03      9.00       1.44   0.02      1.50     2.17    0.01
.98  0.04      9.00       2.33   0.03      1.50     3.50    0.02
.12  0.09      9.00       4.90   0.06      1.50     7.35    0.04
.83  0.02      9.00       1.20   0.02      1.50     1.80    0.01
.80  0.06      9.00       2.98   0.04      1.50     4.47    0.02

.81  0.12      9.00       6.09   0.08      1.50     9.14    0.04
.63  0.13      9.00       6.74   0.09      1.50    10.11    0.05
.0   0.0       9.00       0.0    0.0       1.50     0.0     0.0
.0   0.0       9.00       0.0    0.0       1.50     0.0     0.0
.41  0.13      9.00       6.60   0.08      1.50     9.90    0.05

.98  0.04      9.00       2.33   0.03      1.50     3.50    0.02
.56  0.14      9.00       7.17   0.09      1.42    10.19    0.05
.06  0.01     10.00       0.41   0.01      1.50     0.61    0.00
.62  0.00     10.00       0.16   0.00      1.50     0.24    0.00
.71  0.01     10.00       0.27   0.00      1.50     0.41    0.00

.22  0.00     10.00       0.12   0.00      1.50     0.18    0.00
.0   0.0      10.00       0.0    0.0       1.50     0.0     0.0
.71  0.01     10.00       0.27   0.00      1.50     0.41    0.00
.96  0.02     10.00       1.10   0.01      1.50     1.64    0.01
```

B

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  57  UNK 11                                                  0.0    0.0
  59  C12DMCHX                                               92.57   0.20
                                                             12.99   0.03

  60  UNK 12
  61  UNK 13                                                 12.99   0.03
  62  UNK 15                                                 20.98   0.04
  63  UNK 17                                                 44.12   0.09
  64  UNK 18                                                 10.83   0.02
                                                             26.80   0.06

  65  UNK 19
 651  UNK 19A                                                54.81   0.12
 652  UNK 19B                                                60.63   0.13
  66  UNK 20                                                  0.0    0.0
  67  UNK 21                                                  0.0    0.0
                                                             59.41   0.13

  68  UNK 22
  69  NN                                                     20.98   0.04
  70  UNK 25                                                 64.56   0.14
  71  UNK 26                                                  4.06   0.01
  72  UNK 28                                                  1.62   0.00
                                                              2.71   0.01

  73  UNK 30
  74  UNK 31                                                  1.22   0.00
  75  UNK 32                                                  0.0    0.0
  76  UNK 33                                                  2.71   0.01
  77  UNK 34                                                 10.96   0.02
                                                              1.35   0.00

  78  UNK 35
  79  ND                                                      0.0    0.0
  80  UNK 37                                                 23.14   0.05
  81  UNK 38                                                  1.76   0.00
  82  UNK 39                                                  0.0    0.0
                                                              0.0    0.0

  83  UNK 40
  84  UNK 41                                                  0.0    0.0
  85  OTHER PARAFFINS                                         0.0    0.0
                                                              5.41   0.01

          TOTAL                                          25698.69 55.03
          AVERAGE


  TEST OLSON LAB SAMPLE NO 3  SUZUKI 250
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.98  0.01     8.00      0.37   0.00      1.50     0.56   0.00
.72  0.32     8.00     18.96   0.24      1.46    27.69   0.13
.0   0.0      9.00      0.0    0.0       1.50     0.0    0.0
.57  0.20     9.00     10.29   0.13      1.50    15.43   0.07
.99  0.03     8.00      1.62   0.02      1.70     2.76   0.01

.99  0.03     9.00      1.44   0.02      1.50     2.17   0.01
.98  0.04     9.00      2.33   0.03      1.50     3.50   0.02
.12  0.09     9.00      4.90   0.06      1.50     7.35   0.04
.83  0.02     9.00      1.20   0.02      1.50     1.80   0.01
.80  0.06     9.00      2.98   0.04      1.50     4.47   0.02

.81  0.12     9.00      6.09   0.08      1.50     9.14   0.04
.63  0.13     9.00      6.74   0.09      1.50    10.11   0.05
.0   0.0      9.00      0.0    0.0       1.50     0.0    0.0
0    0.0      9.00      0.0    0.0       1.50     0.0    0.0
.41  0.13     9.00      6.60   0.08      1.50     9.90   0.05

.98  0.04     9.00      2.33   0.03      1.50     3.50   0.02
.56  0.14     9.00      7.17   0.09      1.42    10.19   0.05
.06  0.01    10.00      0.41   0.01      1.50     0.61   0.00
.62  0.00    10.00      0.16   0.00      1.50     0.24   0.00
.71  0.01    10.00      0.27   0.00      1.50     0.41   0.00

.22  0.00    10.00      0.12   0.00      1.50     0.18   0.00
.0   0.0     10.00      0.0    0.0       1.50     0.0    0.0
.71  0.01    10.00      0.27   0.00      1.50     0.41   0.00
.96  0.02    10.00      1.10   0.01      1.50     1.64   0.01
.35  0.00    10.00      0.14   0.00      1.50     0.20   0.00

.0   0.0     10.00      0.0    0.0       1.50     0.0    0.0
.14  0.05    10.00      2.31   0.03      1.40     3.24   0.02
.76  0.00    11.00      0.16   0.00      1.50     0.24   0.00
.0   0.0     11.00      0.0    0.0       1.50     0.0    0.0
.0   0.0     11.00      0.0    0.0       1.50     0.0    0.0

0    0.0     11.00      0.0    0.0       1.50     0.0    0.0
.0   0.0     11.00      0.0    0.0       1.50     0.0    0.0
.41  0.01    11.50      0.47   0.01      1.50     0.71   0.00

.69 55.03            4514.70  57.02            5880.47  28.04
              5.69                       1.30
```

P

E

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    TEST OLSON LAB SAMPLE NO 3  SUZUKI 250                         OLEFINS

  PEAK                        NAME                              PPMC    PCT    CAR

     3   ETHYLENE                                             429.55   0.92     2.
     5   PROPYLENE                                            205.61   0.44     3.
     7   PROPADIENE                                            13.44   0.03     3.
     9   1B IBE 13B                                           189.57   0.41     4.
    11   T2B                                                   98.68   0.21     4.

    12   UNK 1                                                  6.11   0.01     4.
    13   C2B                                                   56.83   0.12     4.
    14   UNK 1A2                                                1.53   0.00     4.
    15   3M1B                                                  41.09   0.09     5.
    17   1P                                                    81.57   0.17     5.

    18   2M1B                                                 169.41   0.36     5.
    20   2M13B                                                  0.0    0.0      5.
    21   T2P                                                  193.08   0.41     5.
    22   C2P                                                   96.39   0.21     5.
    23   2M2B                                                 348.44   0.75     5.

    24   T13P                                                  18.64   0.04     5.
    25   UNK 2                                                  0.0    0.0      5.
    26   C13P                                                   0.0    0.0      5.
    27   CPE                                                   35.44   0.08     5.
    28   4M1P                                                  36.86   0.08     6.

    29   23DM1B                                                40.97   0.09     6.
   291   UNK 2A2                                                0.0    0.0      6.
    30   4MT2P                                                 63.15   0.14     6.
   301   4MC2P                                                  0.0    0.0      6.
    31   UNK 3                                                  3.56   0.01     6.

    32   2M1P 1HX                                             104.33   0.22     6.
    33   2E1B                                                  17.40   0.04     6.
    34   C3HX T3HX T2HX                                       177.96   0.38     6.
    35   2M2P 3MT2P                                           184.53   0.40     6.
    36   23DM13B C2HX                                          39.26   0.08     6.

    37   3MC2P                                                 96.00   0.21     6.
   371   UNK 3A2                                                0.0    0.0      6.
    38   23DM2B 233TM1B                                        33.03   0.07     6.
   381   UNK 3B2                                                0.0    0.0      7.
    39   1MCPE 34DM1P                                           0.0    0.0      6.

    41   5M1HX                                                 14.05   0.03     7.
   411   UNK 3C2                                                5.96   0.01     7.
    42   CHXE                                                  83.39   0.18     6.
    43   5MT2HX 34DMC2P 5MC2HX 34DMT2P                         76.95   0.16     7.
   431   UNK 4A2                                                0.0    0.0      7.

   432   UNK 4B2                                                0.0    0.0      7.
   433   UNK 4C2                                                0.0    0.0      7.
    44   2M1HX 1HP                                              0.0    0.0      7.
   441   UNK 4D2                                               61.41   0.13     7.
    45   2M2HX T3HP C3HP                                       78.96   0.17     7.

   451   UNK 4E2                                                0.0    0.0      7.
    46   244TM1P 3E2P T2HP                                     45.22   0.10     7.
   461   UNK 4F2                                                0.0    0.0      7.
    47   23DM2P C2HP                                           31.62   0.07     7.
   471   UNK 4G2                                                0.0    0.0      7.

    48   UNK 5A2                                                0.0    0.0      7.
    49   244TM2P 4MCHXE 3MCHXE                                 96.91   0.21     7.
   491   UNK 5B2                                                0.0    0.0
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FINS

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  CARBON NO    PPM      PCT    REAC. NO.  REACT    PCT


    2.00     214.78    2.71      2.88   618.55    2.95
    3.00      68.54    0.87      5.93   406.42    1.94
    3.00       4.48    0.06      3.90    17.48    0.08
    4.00      47.39    0.60      6.04   286.25    1.36
    4.00      24.67    0.31     18.98   468.24    2.23

    4.00       1.53    0.02     15.00    22.91    0.11
    4.00      14.21    0.18     12.03   170.90    0.81
    4.00       0.38    0.00      4.00     1.53    0.01
    5.00       8.22    0.10      4.58    37.64    0.18
    5.00      16.31    0.21      3.56    58.08    0.28

    5.00      33.88    0.43      5.76   195.16    0.93
    5.00       0.0     0.0       6.27     0.0     0.0
    5.00      38.62    0.49     13.05   503.95    2.40
    5.00      19.28    0.24      9.15   176.39    0.84
    5.00      69.69    0.88     32.20  2243.93   10.70

    5.00       3.73    0.05      6.80    25.35    0.12
    5.00       0.0     0.0       4.00     0.0     0.0
    5.00       0.0     0.0       6.80     0.0     0.0
    5.00       7.09    0.09     38.98   276.29    1.32
    6.00       6.14    0.08      3.90    23.96    0.11

    6.00       6.83    0.09      3.73    25.47    0.12
    6.00       0.0     0.0       4.00     0.0     0.0
    6.00      10.53    0.13      6.61    69.57    0.33
    6.00       0.0     0.0       6.50     0.0     0.0
    6.00       0.59    0.01      4.00     2.37    0.01

    6.00      17.39    0.22      3.39    58.95    0.28
    6.00       2.90    0.04      3.90    11.31    0.05
    6.00      29.66    0.37      8.40   249.15    1.19
    6.00      30.75    0.39     27.12   834.07    3.98
    6.00       6.54    0.08     20.30   132.82    0.63

    6.00      16.00    0.20     17.00   272.00    1.30
    6.00       0.0     0.0      25.00     0.0     0.0
    6.50       5.08    0.06     52.90   268.78    1.28
    7.00       0.0     0.0      25.00     0.0     0.0
    6.50       0.0     0.0      25.00     0.0     0.0

    7.00       2.01    0.03      2.50     5.02    0.02
    7.00       0.85    0.01      2.50     2.13    0.01
    6.00      13.70    0.18      5.93    82.42    0.39
    7.00      10.99    0.14     11.00   120.91    0.58
    7.00       0.0     0.0      10.00     0.0     0.0

    7.00       0.0     0.0      10.00     0.0     0.0
    7.00       0.0     0.0      10.00     0.0     0.0
    7.00       0.0     0.0       2.80     0.0     0.0
    7.00       8.77    0.11      7.00    61.41    0.29
    7.00      11.26    0.14     11.30   127.46    0.61

    7.00       0.0     0.0      10.00     0.0     0.0
    7.33       6.17    0.08      9.40    57.98    0.28
    7.00       0.0     0.0      10.00     0.0     0.0
    7.00       4.52    0.06     47.00   212.30    1.01
    7.00       0.0     0.0      30.00     0.0     0.0

    7.00       0.0     0.0      30.00     0.0     0.0
    7.33      13.22    0.17     13.00   171.87    0.82
    7.33       0.0     0.0      13.00     0.0     0.0
    7.33       0.0     0.0      13.00     0.0     0.0
    7.00      32.69    0.41      9.73   318.07    1.52
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F

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   38  23DM2B 233TM1B                                   33.03   0.07
  381  UNK 3B2                                            0.0    0.0
   39  1MCPE 34DM1P                                       0.0    0.0

   41  5M1HX                                             14.05   0.03
  411  UNK 3C2                                            5.96   0.01
   42  CHXE                                              83.39   0.18
   43  5MT2HX 34DMC2P 5MC2HX 34DMT2P                     76.95   0.16
  431  UNK 4A2                                            0.0    0.0

  432  UNK 4B2                                            0.0    0.0
  433  UNK 4C2                                            0.0    0.0
   44  2M1HX 1HP                                          0.0    0.0
  441  UNK 4D2                                           61.41   0.13
   45  2M2HX T3HP C3HP                                   78.96   0.17

  451  UNK 4E2                                            0.0    0.0
   46  244TM1P 3E2P T2HP                                 45.22   0.10
  461  UNK 4F2                                            0.0    0.0
   47  23DM2P C2HP                                       31.62   0.07
  471  UNK 4G2                                            0.0    0.0

   48  UNK 5A2                                            0.0    0.0
   49  244TM2P 4MCHXE 3MCHXE                             96.91   0.21
  491  UNK 5B2                                            0.0    0.0
  492  UNK 5C2                                            0.0    0.0
   51  1MCHXE                                           228.83   0.49

   52  UNK 8                                             92.03   0.20
   53  UNK 9                                             96.93   0.21
   54  1OC 2E1HX                                        112.76   0.24
  541  UNK 9A2                                           15.28   0.03
  542  UNK 9B2                                           16.24   0.03

   55  23DM2HX T4OC 2M2HP                                 9.10   0.02
   56  UNK 9C2                                           29.63   0.06
   57  26DM3HP                                           37.26   0.08
   58  T2OC C2OC                                          0.0    0.0
   60  4EECHXE                                            1.26   0.00

  601  UNK 13A2                                           0.0    0.0
   61  UNK 14                                            11.00   0.02
  611  UNK 14A2                                           0.0    0.0
   62  UNK 16                                            35.32   0.08
  621  UNK 16A2                                           0.0    0.0

  631  UNK 17A2                                           0.0    0.0
   65  12DMCHXE                                          76.57   0.16
  651  UNK 19A2                                           0.0    0.0
   67  UNK 21A2                                          53.73   0.12
   68  UNK 23                                            69.81   0.15

   69  UNK 24                                            55.79   0.12
  691  UNK 24A2                                           0.0    0.0
   71  UNK 27                                            37.14   0.08
  711  UNK 27A2                                           0.0    0.0
   72  UNK 29                                             8.29   0.02

  721  UNK 29A2                                           6.57   0.01
  741  UNK 31A2                                           0.0    0.0
   85  OTHER OLEFINS                                      0.0    0.0

           TOTAL                                       4270.41   9.14
           AVERAGE


        TEST OLSON LAB SAMPLE NO 3  SUZUKI 250
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14.05	0.03	7.00	2.01	0.03	2.50	5.02	0.02
5.96	0.01	7.00	0.85	0.01	2.50	2.13	0.01
83.39	0.18	6.00	13.90	0.18	5.93	82.42	0.39
76.95	0.16	7.00	10.99	0.14	11.00	120.91	0.58
0.0	0.0	7.00	0.0	0.0	10.00	0.0	0.0
0.0	0.0	7.00	0.0	0.0	10.00	0.0	0.0
0.0	0.0	7.00	0.0	0.0	10.00	0.0	0.0
0.0	0.0	7.00	0.0	0.0	2.80	0.0	0.0
61.41	0.13	7.00	8.77	0.11	7.00	61.41	0.29
78.96	0.17	7.00	11.28	0.14	11.30	127.46	0.61
0.0	0.0	7.00	0.0	0.0	10.00	0.0	0.0
45.22	0.10	7.33	6.17	0.08	9.40	57.98	0.28
0.0	0.0	7.00	0.0	0.0	10.00	0.0	0.0
31.62	0.07	7.00	4.52	0.06	47.00	212.30	1.01
0.0	0.0	7.00	0.0	0.0	30.00	0.0	0.0
0.0	0.0	7.00	0.0	0.0	30.00	0.0	0.0
96.91	0.21	7.33	13.22	0.17	13.00	171.87	0.82
0.0	0.0	7.33	0.0	0.0	13.00	0.0	0.0
0.0	0.0	7.33	0.0	0.0	13.00	0.0	0.0
228.83	0.49	7.00	32.69	0.41	9.73	318.07	1.52
92.03	0.20	8.00	11.50	0.15	7.00	80.53	0.38
96.93	0.21	8.00	12.12	0.15	7.00	84.82	0.40
112.76	0.24	8.00	14.10	0.18	2.80	39.47	0.19
15.28	0.03	8.00	1.91	0.02	2.50	4.77	0.02
16.24	0.03	8.00	2.03	0.03	2.50	5.07	0.02
9.10	0.02	8.00	1.14	0.01	27.85	31.69	0.15
29.63	0.06	8.00	3.70	0.05	7.00	25.93	0.12
37.26	0.08	9.00	4.14	0.05	6.80	28.15	0.13
0.0	0.0	8.00	0.0	0.0	4.80	0.0	0.0
1.26	0.00	8.00	0.16	0.00	3.05	0.48	0.00
0.0	0.0	8.00	0.0	0.0	6.00	0.0	0.0
11.00	0.02	9.00	1.22	0.02	6.00	7.33	0.03
0.0	0.0	9.00	0.0	0.0	6.00	0.0	0.0
35.32	0.08	9.00	3.92	0.05	6.00	23.55	0.11
0.0	0.0	9.00	0.0	0.0	6.00	0.0	0.0
0.0	0.0	9.00	0.0	0.0	6.00	0.0	0.0
76.57	0.16	8.00	9.57	0.12	15.42	147.59	0.70
0.0	0.0	9.00	0.0	0.0	6.00	0.0	0.0
53.73	0.12	9.00	5.97	0.08	6.00	35.82	0.17
69.81	0.15	9.00	7.76	0.10	6.00	46.54	0.22
55.79	0.12	9.00	6.20	0.08	6.00	37.19	0.18
0.0	0.0	10.00	0.0	0.0	6.00	0.0	0.0
37.14	0.08	10.00	3.71	0.05	6.00	22.29	0.11
0.0	0.0	10.00	0.0	0.0	6.00	0.0	0.0
8.29	0.02	10.00	0.83	0.01	6.00	4.97	0.02
6.57	0.01	10.00	0.66	0.01	6.00	3.94	0.02
0.0	0.0	10.00	0.0	0.0	6.00	0.0	0.0
0.0	0.0	11.00	0.0	0.0	6.00	0.0	0.0
4270.41	9.14		900.23	11.37		9247.14	44.09
		4.74			10.27		

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 TEST OLSON LAB SAMPLE NO 3  SUZUKI 250                          AROMATICS

PEAK                      NAME                          PPMC     PCT   CARBON N

  39  BZ                                              1243.25   2.66     6.00
  50  TOL                                             7444.21  15.94     7.00
  63  EBZ                                              691.83   1.48     8.00
  64  PX MX                                           1882.07   4.03     8.00
 652  PHEE (STYRENE)                                     0.0    0.0      8.00

  66  OX                                               877.36   1.88     8.00
  70  IPRBZ                                             32.61   0.07     9.00
  73  NPRBZ                                            181.64   0.39     9.00
  74  1M3EBZ 1M4EBZ                                    695.74   1.49     9.00
  75  135TMBZ                                          259.99   0.56     9.00

 751  UNK 32A3                                           0.0    0.0     10.00
  76  1M2EBZ 2PH1PR                                    391.61   0.84     9.00
 761  UNK 33A3                                           0.0    0.0     10.00
  77  C1PH1PR TBBZ 124TMBZ                             904.06   1.94     9.33
  78  IBBZ SBBZ                                         47.08   0.10    10.00

  79  UNK 36                                             7.44   0.02     9.50
  80  1M3IPRBZ 123TMBZ                                 154.12   0.33     9.50
  81  1M4IPRBZ T1PH1PR                                  54.77   0.12     9.50
  82  1M2IPRBZ                                          21.65   0.05    10.00
  83  13DEBZ 1M3NPRBZ                                  179.10   0.38    10.00

  84  1M4NPRBZ NBBZ 12DEBZ 13DM5EBZ 14DEBZ              71.39   0.15    10.00
  85  OTHER AROMATICS                                  782.71   1.68    11.00

          TOTAL                                      15922.49  34.09
          AVERAGE                                                        7.59

                                                                 ACETYLENES

PEAK                      NAME                          PPMC     PCT   CARBON N


   4  ACETYLENE                                        803.33   1.72     2.00
 107  MA                                                 8.24   0.02     3.00
  13  EA WITH C2B                                        0.0    0.0      4.00

          TOTAL                                        811.57   1.74
          AVERAGE                                                        2.01


          GRAND TOTALS                                  PPMC
                                                     ********* 46702.89
                                    AS HEXANE        7783.844

          MAGA INDEX      0.674
          GM INDEX        2.649
          AVE. C NUMBER   5.899
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         AROMATICS

  PPMC     PCT    CARBON NO    PPM      PCT    REAC. NO.  REACT     PCT

 43.25    2.66      6.00     207.21    2.62      0.56   116.04     0.55
 44.21   15.94      7.00    1063.46   13.43      2.20  2339.61    11.16
 91.83    1.48      8.00      86.48    1.09      2.03   175.55     0.84
382.07    4.03      8.00     235.26    2.97      4.92  1157.47     5.52
  0.0     0.0       8.00       0.0     0.0       3.50     0.0      0.0

877.36    1.88      8.00     109.67    1.39      3.64   399.20     1.90
 32.61    0.07      9.00       3.62    0.05      1.64     5.94     0.03
 81.64    0.39      9.00      20.18    0.25      1.70    34.31     0.16
 95.74    1.49      9.00      77.30    0.98      4.10   316.95     1.51
 59.89    0.56      9.00      28.88    0.36      8.64   249.50     1.19

  0.0     0.0      10.00       0.0     0.0       6.00     0.0      0.0
 91.61    0.84      9.00      43.51    0.55      3.40   147.94     0.71
  0.0     0.0      10.00       0.0     0.0       6.00     0.0      0.0
 04.06    1.94      9.33      96.90    1.22      3.20   310.07     1.49
 47.08    0.10     10.00       4.71    0.06      1.00     4.71     0.02

  7.44    0.02      9.50       0.78    0.01      5.00     3.91     0.02
 54.12    0.33      9.50      16.22    0.20      5.80    94.09     0.45
 54.77    0.12      9.50       5.76    0.07      3.00    17.29     0.08
 21.65    0.05     10.00       2.17    0.03      2.90     6.28     0.03
 79.10    0.38     10.00      17.91    0.23      4.20    75.22     0.36

 71.39    0.15     10.00       7.14    0.09      3.40    24.27     0.12
 82.71    1.68     11.00      71.16    0.90      5.00   355.78     1.70

 22.49   34.09              2098.32   26.50            5834.11    27.82
                    7.59                         2.78

         ACETYLENES

  PPMC     PCT    CARBON NO    PPM      PCT    REAC. NO.  REACT     PCT

 03.33    1.72      2.00     401.66    5.07      0.0      0.0      0.0
  8.24    0.02      3.00       2.75    0.03      3.90    10.72     0.05
  0.0     0.0       4.00       0.0     0.0      18.98     0.0      0.0

 11.57    1.74               404.41    5.11              10.72     0.05
                    2.01                         0.03


  PPMC                         PPM                     REACTIVITY
******* 46702.89            7917.520                   *********
3[illegible].844                                        20971250
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J